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NUCLEAR REGULATORY COMMISSION

Title: Private Fuel Storage, LLC

Docket Number: 72-22-ISFSI; ASLBP No. 97-732-02-ISFSI

Location: Salt Lake City, Utah

Date: Monday, April 29, 2002

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:	)	
	)	
PRIVATE FUEL STORAGE, LLC,	)	Docket No. 72-22
(Independent Spent Fuel	)	ASLBP No.
Storage Installation)	)	97-732-02-ISFSI
	)	

U. S. Nuclear Regulatory Commission
Sheraton Hotel, Wasatch Room
Salt Lake City, Utah 84114

On April 29, 2002 the above-entitled matter came on for hearing, pursuant to notice, before:

MICHAEL C. FARRAR, CHAIRMAN
Administrative Judge
U. S. Nuclear Regulatory Commission

DR. JERRY R. KLINE
Administrative Judge
Atomic Safety & Licensing Board Panel

DR. PETER S. LAM
Administrative Judge
Atomic Safety & Licensing Board Panel

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I N D E X

E X A M I N A T I O N

E X H I B I T S

Monday, April 29, 2001 9:00 a.m.

P R O C E E D I N G S

JUDGE FARRAR: Good morning, everyone. It's 9:00 here at the Sheraton on Monday April 29th. We're about to begin what I think all would agree is the most complicated and longest of all the issues we'll be hearing here, that involving seismic and geotechnical issues.

As you can see, you've got the same old board up here, but I see we have an entire -- almost an entirely different cast of legal characters. On that score, one of our law clerks -- one of our two clerks, Will Keizer is here, and why don't we start with introductions of counsel for the State.

MS. CHANCELLOR: Dennis Chancellor for the State of Utah. On my left is Dr. Diane Nielson representing the State of Utah.

MS. NAKAHARA: I'm Connie Nakahara with the State of Utah, and I have with me an expert witness, Dr. Steven Bartlett.

JUDGE FARRAR: For the company?

MR. GAUKLER: Paul Gaukler, Shaw

Pittman. I have with me Matias Travieso-Diaz on my right and Blake Nelson on my left.

JUDGE FARRAR: For the Staff?

MR. TURK: Good morning, Your Honors. Sherwin Turk for NRC Staff. To my right is Martin O'Neill, also from the General Counsel's office. And I'd like to point out that I have with me a team of experts for the Staff today. First, we have Mark Delligatti sitting behind me, who is project manager for the PFS application. We also have in the audience, Dr. John Stamatakos. And if you'd like, should I ask them to stand, Your Honor?

JUDGE FARRAR: Or wave their arms.

MR. TURK: First Dr. John Stamatakos, Dr. Martin McCann, Dan Pomerening, Dr. Goodluck Ofoegbu, and Dr. Mahendra Shah. Have I left anyone off? Excuse me, Jack Guttmann sitting directly behind me. And I'll give a list of names to the reporter so she has the spellings.

MR. GAUKLER: Your Honor, I'd like to do the same. Behind me, I have Dr. Kris Singh of OPEC. Max Bunnell from XL, Alan Soler from OPEC. Dr. Wen Tseng from ICEC, Dr. Robert Youngs from Geomatrix and John Bunnell, project director, PFS.

MS. CHANCELLOR: Your Honor, I forget

one person. Barry Solomon, who is one of the State's witnesses.

JUDGE FARRAR: Fine, thank you.

Before we get started, the Board wanted to make a general comment, not about the merits of the evidence, but about the effort that counsel has undoubtedly put into all this. In reviewing it, the way you've organized enormous amounts of testimony on a very complex subject is something to be applauded. Mr. Gaukler, at a pre-hearing conference, referred facetiously to the Company having unlimited resources, meaning that law firms have a lot to draw on. I know that cost your client, you know, that that doesn't come free to your client. But notwithstanding that, you've done a very credible job. Mr. Turk, the same for the Staff. I know you have what we refer to as an army of regulators to draw on, but they have other assignments, I know it's difficult.

Ms. Chancellor, I want to particularly compliment you. I've had a lot of experience with State Government in my life, and in some states, the opposition of the governor and the state legislature might not necessarily filter down in terms of an army of resources for you. The last we

checked with you, there was a chance you might be locked out of your office during the Olympics. I'm sure that was -- while the rest of us were enjoying the games on television, I'm sure that was not an easy time for you. And so we particularly want to take note of the work you've done to put your case together. That should be noted. Not that these comments have anything to do with the merits of the issues, but just recognizing all the effort you all have put together.

We had talked last Thursday at the hearing on the seismic motions about how and where to complete this case. The parties -- and we recognize that the estimates that the parties gave us about how long it would take to try issues were proving to be off by close to a factor of two. We're scheduled here for three more weeks. After that discussion, when we indicated that after the six weeks, we were inclined to take a break and head back to D.C., the State was concerned about that suggestion. Ms. Chancellor sent us and the parties an E-mail, I think on Saturday, asking to address that matter at the beginning today. As it turned out, the Board had already been talking about different options we might come up with.

Ms. Chancellor, why don't you go ahead and tell us what's on your mind.

MS. CHANCELLOR: Yes, Your Honor. I'd just like to give a little background. The State first became aware of the PFS project about five years ago and the State formally entered the NRC proceedings about four and a half years ago. Being an non-nuclear state, we had to learn the unique facets of the legal system that NRC has created. A system that is like no other judicial or administrative proceeding we have been involved in. The State has tried mightily to comply with NRC procedural requirements. We've filed over 60 contentions, most of which had to be filed within 30 days of knowing about an event. And some of which involve very, very technical analyses. We filed amendments to those contentions, we have complied with NRC requirements by submitting detailed and technical declarations in support of summary disposition. And we have filed prefiled testimony that runs for hundreds of pages.

The State has not been an obstructionist. Even the Board has complimented the State on the caliber of its work. The State has shown a willingness to settle issues such as

DD, where prior to hearing, the State opted for PFS's payment of a paragon study. The State has cooperated with counsel for PFS and NRC in the management of this case. In general, we have worked through procedural and timing problems and brought forward the unified suggestions or schedules to the Board. This cooperative effort has reduced the workload on the Board by it not having to arbitrate between squabbling parties on procedural issues. To date, the State has had the opportunity to go to trial on its contentions on three occasions in 2000 and three occasions in 2002. Financial assurance, decommissioning and emergency response in June of 2000. Those hearings were held in Salt Lake City. The current hearings involve hydrology, aircraft crashes and seismicity.

With respect to the current hearings, at the pre-hearing conference on January 17, 2002, the Board raised the possibility of holding hearings in Rockville, Maryland on aircraft crashes, but decided that hearings on all the remaining issues would be held in Salt Lake City. The Board agreed with the State's argument to accommodate the State's request that the entire hearings would take place in Utah, rather than at the Licensing Board's

hearing room in Rockville, Maryland. The issues set for hearing included Utah L/K and L/QQ, and as the Board stated in its order on March 1, 2002, the hearings on these issues shall continue day-to-day until concluded. The State understood that the hearings would be held in Salt Lake City. This is particularly the case with the complex seismic issue.

During oral argument on Thursday, April the 25th, the State received one of the harshest rulings that has been delivered by this Board in the four and a half years that the State has been involved in the PFS proceeding. The Board suggested that the balance of the hearings after the conclusions of the hearings in Salt Lake City on May 17, will be held in Rockville, Maryland. This surely means that up to two weeks of hearings on seismicity will be held in Rockville.

The reason for the State's distress at the Board's ruling may not be obvious. But let me explain. The State's key experts on seismicity are involved in the PFS proceeding because they agree with the State's concern that PFS's seismic analysis of the Skull Valley site should be peer reviewed. They are concerned about science, they

are not obstructionists. I think the State has shown that it is concerned about technical issues, where it showed a willingness to settle Utah O, because PFS at last decided to put in a monitoring system. The State's key experts are located in Salt Lake City and California. Two experts are on the east coast, but those experts do not address most of the issues in Utah L/QQ. That is Dr. Mitchell and Dr. Resnikoff. The State's experts are not full-time consultants who are in this proceeding to make a profit. They are not hired guns. All of the State's experts have other full-time jobs. Because the State's experts have other full-time jobs, they cannot commit to two weeks of hearings in Rockville, Maryland. Dr. Bartlett is a good example. He recently joined the engineering faculty at the University of Utah. He has committed to the University to direct graduate studies during the next two months. If hearings are held in Salt Lake City, he will be able to meet with his students, but he will not be able to do so if he is in Maryland for two weeks.

With the exception of dose limits, anything that is left in the hearing, will require Dr. Bartlett's attention. Dr. Bartlett has been

the linchpin in assisting the State's attorneys in their understanding of very complicated concepts involved in earthquake engineering. The State cannot go forward in the hearings in cross-examining PFS's witnesses or the Staff's witnesses without Dr. Bartlett's assistance.

In addition, some of the State's attorneys have preschool children, and it would be an extreme hardship for them to travel for two weeks.

With respect to PFS, PFS builds itself as being backed by utilities with a wealth of assets. PFS is represented by probably a 200-member law firm, a law firm that specializes in NRC proceedings. PFS's lawyers also have qualifications -- technical qualifications, so assistance by their experts is not as critical as it is for the State's attorney.

Some of PFS's witnesses are located in the west or the west coast. For example, Dr. Youngs and Dr. Tseng, I believe come from California. PFS is represented by the largest law firm in Salt Lake City; Parsons Behle & Latimer. Parsons, Behle & Latimer is located a short distance from the hearing room -- from the hearing

location here, a couple of blocks down the street. PFS -- Parsons Behle & Latimer have their own copy center. PFS has a document repository set up at Parsons Behle & Latimer. Therefore, PFS does not have to haul all of its documents to Salt Lake City as the State would to Rockville. There are no resources available to the State in Rockville.

NRC Staff: The burden is not on the Staff in this proceedings. The Staff has taken a position that is supportive of PFS. The Staff can and does share documents with PFS. Counsel for NRC says that NRC has a stable full of experts. Many of those experts are also located in the west. Furthermore, the Staff receives almost $2,000,000 in annual licensing fees from PFS. I think with respect to a level playing field, the critical point is that the facility will be located in Utah. Analogizing to something we've had to deal with for a long time, good cause and filing late filed contentions. A location of the facility should be the overriding criteria here just like good cause is in late file contentions.

NRC case law states that most hearings are held in the vicinity of the site.

I think it's important to note that the

State is up against two opponents; PFS and the Staff. The State is up against a company backed by eight utilities, plus the State is also up against a Federal agency. At the very least, the State should have the home court advantage.

While NRC may not consider cost to be important, they are a reality. Like most government agencies, the State must live within its budget. If the State had to spend dollars on two weeks of travel, the money allocated for experts will also have to pay for hotel costs, office equipment rental, living expenses for witnesses, attorneys, clerical assistance. It's important to note that Utah L/QQ is an important safety issue. We are dealing with one of the most critical issues in this proceeding. This is not a squabble about procedure, it's all about safety. By holding hearings in Rockville, you will be denying the State to fairly present its case to the Board. After a tenacious effort to keep the seismic issues from being dismissed on procedural grounds, the Board should allow the State to take its best shot. Only by holding the hearings in Salt Lake City will there be anything close to a level playing field. We recognize the hardship on the Board in having to

come to Salt Lake City and appreciate their willingness thus far to hold hearings here. But the burden on presenting these technical issues to the Board will take all the reserve that the State has, and that reserve will show empty if we're forced to go to Rockville.

Your Honor, with permission, I'd like Dr. Nielson to address the Board.

JUDGE FARRAR: Certainly.

DR. NIELSON: Your Honors, we appreciate very much the efforts that you have taken to bring not only these hearings to Salt Lake City but also the limited appearance hearings. You have been very fair in dealing with the citizens in this State in those limited appearance hearings, and very considerate of their interests and positions. You have also been very considerate of all of us in recognizing the importance thus far in being here in Salt Lake City.

I would ask you on behalf of the State of Utah to recognize the importance of holding these hearings here because of the location of the proposed facility in Utah, to recognize that many times, although you won't see citizens here during the day, it doesn't reflect a lack of interest or

commitment to this issue on their part. Like all of us who are here, they also have eight to five jobs, and while I realize many times this board and the parties have gone well beyond 5:00 in those hearings, the public doesn't know that, and so assuming that they're nine to five, they many times would not come over here at the end of a busy day, even though they might otherwise, knowing the hearings were continuing.

We're anxious to have you return here after the completion of the next three weeks, and we're willing to work with you in any way we can to assist in finding space for these hearings. But I would urge you on behalf of the issues before the State and the location of this facility to reconsider and hold the remainder of the seismic hearings here in Utah. Thank you very much.

JUDGE FARRAR: Ms. Nielsen, Ms. Chancellor, thank you for those eloquent statements of how particular -- particularly how it would benefit the State in presenting its case and have us here. When we spoke on Thursday, we had in mind, Ms. Chancellor, I think at the pre-hearing conference when we talked about having that one week of hearings in the D.C. area, that you had --

our recollection was that you had focused primarily on wanting the citizens of Utah to be able to observe, and as we pointed out on Thursday and for Ms. Nielson maybe for exactly the reasons you mentioned, the public has not been showing up, and so we had that factor paramount at that time. You've made a strong argument for us reconsidering that suggestion. Let me see what the other parties have to say. Mr. Gaukler?

MR. GAUKLER: Yes, Judge Farrar, thank you. We would like to say at the outset, I agree with Ms. Chancellor that the parties have worked together on procedural issues to minimize any disputes for the Board, and we have a good working relationship on that.

With respect to the other matters. I would note that the State has experienced NRC counsel that's been advising the State from the beginning of this proceeding, a law firm from Washington D.C. who is experienced in nuclear issues. In terms of the broader pictures, the State is not your typical intervenor. It has large resources available to put -- it should be capable of transporting documents and finding resources necessary in the D.C. area to support a hearing

there just as much as PFS is able to support a hearing here in Salt Lake City.

Further, it's my fervent hope that we will not have to have two weeks of hearing after the three weeks here. It's my fervent goal, PFS's fervent goal, to get through most of the seismic issues in two weeks, and hopefully we'll have a limited number of issues left, such that any need for a hearing back in D.C., would be minimal in terms of the witnesses involved, the time involved and other things. And minimal in terms of documents that have to be transported back to the D.C. area.

JUDGE FARRAR: Thank you, Mr. Gaukler. Mr. Turk, does the Staff have a position?

MR. TURK: Yes, Your Honor. I want to say first of all, that I appreciate that Ms. Chancellor sent the E-mail to everyone advising us that she would like to rise the issue today. It gave me an opportunity to do a little looking into past precedent. And I would note first of all that the Staff does not have a preference as to whether we are here in Salt Lake or back in Rockville. We're well aware of the Commission's general policy, favoring hearings in the vicinity of the

site. The people in Salt Lake have been most hospitable. It's not hard duty to be here, except for having to be away from families and the disruption in our personal lives.

I would note, however, that under 10 CFR Section 2.718(e), the Licensing Board is granted the authority to regulate the course of the proceeding and the conduct of the participants. In a 1982 case involving the Indian Point Plant, this is CLI 82-15, the Commission indicated that the Licensing Boards have broad discretion to regulate the course of the proceeding including the location of hearings. And I would commend that decision to Your Honors in terms of its lending support to whatever decision you ultimately decide is appropriate; whether it's to stay here in Salt Lake City or to go back to Rockville.

There are other cases in which the Commission itself has ordered that hearings be held in Washington or Maryland, rather than at the vicinity of the site. For example, when the Commission established an inquiry into the Three Mile Island falsification of data, they directed the hearings be held in Washington, and that is in CLI 85-18.

In an early Licensing Board decision involving the Washington Public Power Supply System, which, of course, is located way out in the State of Washington, the hearings were convened back in Washington D.C., and that decision is LBP 77-49 involving the WPPSS, nuclear projects three and five.

And finally, I would note that in a different kind of proceeding, when the Commission had opportunity to look at a petition for rule making in which the Citizens Advisory Board for the planning council for Omaha, Nebraska and Council Bluffs, Iowa requested that all hearings be held near the reactor itself, near the site of the facility. The Commission noted -- and this is a decision by the commissioners in DPR 81-1. The Commission noted that while it's generally the policy of the commission to hold hearings in the vicinity of the site, it's appropriate to take into account the budgetary and personnel limitations.

And I think that what these decisions all show is that while the Commission certainly favors holdings hearings in the vicinity of the facility, there are other considerations that can and should be taken into account, such as hardship

to other participants. And to the Licensing Board members itself. In fact, there is an appeal board case in which the appeal board in Three Mile Island decided to convene hearings in the Washington area because of the difficulty that traveling to the Harrisburg area would impose on the appeal board members. Ultimately, the appeal board decided to hold those hearings in Harrisburg anyway. But there is a decision in which they indicated that their own schedules for other matters in which they were involved, dictated that hearings should be held in the Washington D.C. area.

I'd like to respond if I may to a few remarks made by Ms. Chancellor. First of all, I would note that it is true that in this proceeding, the State is facing testimony from both the Applicant and from the NRC Staff, which indicates that in the view of those two parties, the facility may be constructed on its proposed site without undue hazard. So in effect, the State does have to cross-examine two other parties, whereas neither the Applicant nor the Staff is faced with that burden. So we recognize that that is an additional hardship for the State. But that's the way it shakes out. I was present during many meetings,

involved in much correspondence between the NRC Staff and the Applicant, in which the Staff was not satisfied with what the Applicant had done early in this proceeding. And indeed at one point, the Staff came close to terminating its review of the application before additional work was done by the Applicant to meet Staff requirements.

So that the position we're in now reflects much development over the course of the past several years in which the Applicant has satisfied the Staff as to the adequacy of its seismic design.

The State mentioned in its view, the Staff can and does share documents with the Applicant. I'm not aware of that. It may be that if someone doesn't have a document handy in the course of a hearing, we may have passed the document to review, but aside from that, I'm not aware of sharing the documents. And, in fact, if I was sitting next to the State, I would be doing the same thing with them. If they needed a document, and I needed a document, I would have no hesitation in sharing with the State.

The burden that the State describes in terms of having to haul its experts and its

document to Washington, is the same burden faced by the Staff. As I mentioned early on, as we started the proceeding today, we have with us many people in the room who have traveled here from different locations, including Texas and California and Washington D.C., and it's a burden on everyone to have to travel from their homes.

So my hope is that in the next two weeks or three weeks, we conclude all hearings, and I think at this point, it's really premature to argue whether or not we should move to Washington three weeks hence. I think if all parties cooperate and we do our utmost to conclude cross-examination in a timely manner, I don't see why the next two or three weeks wouldn't be enough time to here all issues and to close the hearings without requiring the State to move to a different location.

And finally, I would note that in the past, I have had occasion to talk with Ms. Chancellor personally, and on several occasions I've told her that I was very impressed with the quality of the work that the State had done, particularly in its bringing of contentions. I think they've done far more than intervenors normally do. The level of their expertise and the

quality shown in their drafting of contentions has been suburb. Many of those contentions were supported by the Staff. In fact, I think back to the original order in this proceeding in the contentions. Virtually every single one of the contentions that the board admitted in LBP 98-7 was not opposed by the Staff. And with respect to late file contentions, there have been occasions in which we've also supported late file contentions. So I think I would like to join with the Board in recognizing the great effort that the State has put in and the quality of their work.

JUDGE FARRAR: Let me make several comments on behalf of the Board before we continue the discussion. No. 1, whoever -- I think it was you, Mr. Turk, mentioned the cooperation among the parties. We've commented on that before, and it has been extraordinary. We have not been called upon to resolve any petty squabbles, but only serious matters, and that's a credit -- procedural matters, and that's a credit to the way counsel is working together, which was evident at the oral argument we held on Thursday.

No. 2, Ms. Chancellor, that was great courtesy to your fellow counsel to give them an

alert that you did want to discuss this this morning so that they would have time to prepare. I'm particularly happy, Mr. Turk, that you found the case that said the convenience of the Board is significant, because in 2.703(b), it listed three factors; the convenience of the parties or their representatives, the nature of the proceeding and the public interest. So I'm glad to see at some point in the Commission's history, the convenience of the Board was taken into account. But I think our convenience is a lesser concern than the types of other matters that you all have been talking about.

We did take a look at the witness list -- oh, I'm sorry, Mr. Turk, you also mentioned in point, and it was not that case, but it was an earlier Indian Point seismic case. A generation ago when I was on the former appeal board where we took additional evidence in the case on seismic, took about three weeks, if I remember, we had the first three days in White Plains, no one from the public showed up and so we moved the rest of it to D.C.. But if I remember correctly, the intervenor's counsel was from D.C., and there was no particular New York City, New York State focus

of the experts.

We've looked at the witness list here. There are 21 panels and we'll get to another aspect of that number in a moment. As we see it, there are 10 witnesses -- 21 panels consisting of a total of 25 witnesses, although, Ms. Chancellor, I do note that Dr. Bartlett is on as quadruple duty with you. From the 25 witnesses, 10 are from the east, 12 are from the west, and three are from Texas. Not to demean Texas, but I assume going to Salt Lake or D.C. is pretty much the same when you're from San Antonio. However, if you focus just -- so, you know, there's no balance there unless you look specifically at the State witnesses where you've got two from the east and five from the west, including Dr. Bartlett.

We got 21 panels of witnesses. You estimated 10 days for the seismic proceedings. A couple of weeks ago, someone sent us an E-mail saying, you know, it ain't gonna happen.

What also isn't going to happen is any repeat of the experiments we tried two nights where we went until 9 p.m.. To the public it might sound like wow, that's great, they're really getting their work done and working hard at it, but we

found that's too big of a strain on everybody and you lose -- you lose focus, tempers get short, and it is -- I think, Mr. Turk, you used the marathon analogy. You get through a marathon by a slow, steady pace. And so our plan is -- and we'll discuss this further with you, because you are the people even more than us that have to work in the evenings and through the night to get ready for the next day. You know, having a schedule that's nine to five, nine to 5:30, being willing to go an extra half hour, if it means finishing up a panel or getting something particularly done, but not being on a steady 10 or 12-hour schedule. If you went nine to five, that's eight hours, hour for lunch, hour for lost time, you really have six hours of hearings. And my colleagues back home who run hearings for a lot longer than I have, have said that's about all you can expect on a long-term case. If you look at the six hours -- and let's just take a witness put on by the Applicant. If the direct took a half an hour getting the witness sworn, getting the exhibits in, getting them marked, if the Staff, which usually had a short cross-examination of Applicant witnesses, if they took a half hour, if the State did three hours

worth of cross-examination, the Board had a half hour of questions, if the Applicant had an hour of redirect and recross and the spinning out of the re-re efforts took a half hour, that's your six hours. That means unless there's some witnesses we can handle real short, 21 panels of witnesses take 20 days, four weeks of hearing.

Whatever we decide in the next few minutes about future locations of the hearing, we recognize we're going to have some ground rules for counsel, we're going to have some ground rules for witnesses. I'm delighted most of the witnesses are here. If you're not, I'll expect counsel to pass on the remarks. But we're going to have some measures that I think will increase the efficiency of the hearing without limiting anyone's rights.

The Board members had talked over the weekend about how we might resolve this, and looking at a potential four weeks of seismic hearings rather than the two weeks that all counsel equally misrepresented to us in terms of how fast we could proceed. If we stayed -- well, we were supposed to be here six weeks. Weeks four and five were seismic, week six was a spill-over. If we could rearrange witness schedules to use week six

as a seismic week, we'd be willing to stay an extra week seven and therefore have four weeks of seismic beginning today and going right through and proceeding on that basis. Now, I know the problem there is, there was some expectation you'd do aircraft in that spill-over week. I'd be less concerned about taking aircraft to D.C.. I know Ms. Chancellor would be less concerned because that would fall on poor Mr. Soper. Taking aircraft to D.C. because relatively little is left of that. The State's witness is from New York, the State witness that hasn't been heard from is from New York City, and that would be a simpler matter to do in D.C. than two weeks of seismic. If we did two weeks of seismic, you're right, you have to move your entire operation there.

Give me a moment to confer with my colleagues.

MS. CHANCELLOR: Your Honor, if I may, Dr. Bartlett has a commitment the week of May 13. It's a long-standing conference that he has to present at.

JUDGE FARRAR: And I note that someone -- Mr. Turk, did you send us an E-mail that -- when I say us, all E-mails have gone to all parties,

with a number of conflicts in it that different parties had?

MR. TURK: We sent one listing some Staff conflicts. I think the Applicant may have some, as well. But I think if the parties can work that out in terms of scheduling which panel is heard when, you know, we can try our best to make sure everyone is heard when they're available.

JUDGE FARRAR: And remember, we're not a jury and I know -- in fact, we've even started making charts of the witnesses to track who needs to be heard when. But we're willing to take evidence in not the normal order. In other words, you all are starting today with Part D rather than Part C of the contention, so as far as we're concerned, intellectually, we're willing to wrestle with the problem of taking witnesses out of order and then eventually fitting that back into the matrix. Ms. Chancellor?

MS. CHANCELLOR: I think what is fairly set in terms of what can be heard in the next two weeks is that we should be able to get through Section D. And while we may have some conflicts day-to-day, I think that it would be realistic to say that Section D could be completed in two weeks.

JUDGE FARRAR: Nine panels?

MR. GAUKLER: And Section C doesn't take that long. We have two panels, basically for Section C, and I would hope to get Section C done, as well.

MS. CHANCELLOR: I listened to Mr. Gaukler before, and that's why I agreed to two weeks, but I'm not sure I agree this time.

MR. TURK: Your Honor, I'm hoping we can do E in these next two weeks, also. And maybe one way we could do this --

JUDGE FARRAR: Okay, now, I told you all that I'll accept any written -- on Your Honor as lawyers, I'll accept on the rest of the case, any representation about anything other than how long something is going to take.

MR. TURK: Well, I didn't say --

JUDGE FARRAR: I'm watching Mr. Turk.

MR. TURK: I didn't say I think we can, but I'm hoping we can.

JUDGE FARRAR: Well, except it sounds good, but when I sit down and plot out the hours, it's six hours of panel unless there's somebody here who's just giving background testimony that everyone agrees to. And while I can say, yeah,

we'll push harder, when you add up the hours in the day and if you quit at 5:00 most days and, you know -- and believe me, if we could go longer during the day and that would help, I would do it. But we found on the two occasions we did it, it didn't help. It actually, if anything, it probably hindered the process. It wore everybody out and there were certainly diminishing returns. I mean to the public it may look like you're just sitting here and what's the big deal, and anyone who's ever been in litigation knows how wearing it is on the participants.

JUDGE LAM: Now, to estimate the reliability of everybody's estimates today, tell me how did the parties come up with two weeks schedule to begin with?

MR. TURK: I'm going to point my finger to my left, to the other two parties.

JUDGE LAM: Was it a grossly optimistic estimate?

MR. GAUKLER: I don't know if it was grossly optimistic. I think in talking with Ms. Chancellor, we came up with five days for D, three days for E and two days for C. And we were making estimates based on how long we thought it

would take to go through the various witnesses and --

JUDGE FARRAR: Did you know then, Mr. Gaukler, that you would have 21 panels?

MR. GAUKLER: Well, we talked specifically about witnesses and talked specifically about how long we thought it would take to go through the Applicant's witnesses and the State's witnesses and the Applicant's witnesses, and we had basically our witnesses identified at that time.

MR. TRAVIESO-DIAZ: Yes, I'd like to make another point which is not obvious. Even if you know how many people you're going to have, it is not until you start drafting the testimony and also reviewing what you get from the other parties, that you realize the enormity of the things that need to be covered, you're going to cover them well. So if it was a misjudgment, it was perhaps based on the sufficient information as opposed to any gross optimism on our part.

JUDGE FARRAR: Having heard you say that, that's a good point for me to point out, then, that we do not view ourselves as responsible for this schedule. This is a schedule you dreamed

up before that testimony was arrived at, and I would hate to see any suggestion that it was the Board's fault that this hopelessly optimistic schedule was not met.

MR. GAUKLER: I would say that another thing that we took into account was after the first week, we saw things were taking longer, so we went back and reevaluated. That was another factor that went into the E-mail that we decided to send to the Board last week or the week before last.

JUDGE FARRAR: All right.

(Judges conferred off the record.)

JUDGE FARRAR: What we would like to do, rather than make a decision, is leave some options with the parties, and you feel free to come up with your own options. We could stay the seventh week here, do four weeks of seismic, take a break, go back to D.C. and have -- do aircraft, the end of aircraft in D.C.. We could stick to the original schedule here, do two weeks of seismic here, use the spill-over sixth week to finish aircraft here, everybody take a break -- and Ms. Chancellor, you made a powerful argument this morning -- and we would come back to finish seismic here. We could cut my time periods in half and finish 21 panels in

two weeks, and I get some kind of Nobel prize, the Board and I would share a Nobel prize and jurisprudence or something, but I don't see that happening. Or we'll do -- do you all have a better plan? So why don't we wait a day or two, you all work out what you all think about that. But, in essence, Ms. Chancellor, in large respect, your motion that we reconsider, what was not a final decision but a suggestion, is well taken, and in essence, granted with some loopholes.

MS. CHANCELLOR: Thank you, Your Honor. The seventh week, do you mean the week of May 13 when you refer to the seventh week?

JUDGE FARRAR: No.

MS. CHANCELLOR: Or do you mean the week of the 20th?

JUDGE FARRAR: The 20th. May 13th is the sixth week, even though we were off that second week, because other issues that we thought might get heard didn't have to be heard. When I say the sixth week, I mean the week of May 13th, what we've called the spill-over week. The seventh week is the week of May 20th.

In light of the discussion we've just had, no one's going to object to the following

admonitions. In terms of witnesses, I don't care what your lawyer -- or we don't care what your lawyers tell you, answer our questions, answer the parties questions. We've seen already witnesses who were very forthcoming and witnesses who were not, and it's in your interest to have us believe that you're sharing your real thoughts with us. These cases with expert witnesses are not about demeanor credibility where you look in someone's eyes and say, ah-hah, I know the person is lying when they say the light was red when it's really green. But what is at stake is the strength of the opinions that you bring to the table, why you hold those opinions, having been thoughtful about competing opinions. Can you explain away another expert's opinions, and you do that by being forthcoming.

Now, having said that, there are times when you don't want to be too forthcoming and I was just about to mention as the tape ran out, once the court reporter -- when the court report says, what's that, all you need to do is repeat the exact words you just gave. You don't have to give -- repeat your doctoral dissertation on why you said what you just said. When she puts up her hand and

says, she didn't get it, just repeat your words.

Don't use acronyms without spelling them out. Someone the other day said it was in the SAR. Now, these court reporters have been around a long time, and they've been taking depositions, and maybe they knew that was the S-A-R, the Safety Analysis Report. But when you say SAR, that's not a word to most people. If you're going to say it, say what you mean, use the abbreviation. At that point, some counsel may interrupt, and if it's something they don't know about, ask you to explain a little more about what it is. But try to listen. Now, there will be times when we ask you a question and we'll -- you know, listen to the cue. Are we saying we want to discuss this now or are we asking you, what does that stand for? And particularly if I say, just so the record will be clear, that means give the short explanation, not the long one. Don't overstate, don't understate. You want us to respect your expertise, don't make statements that go too far, don't withhold information.

Just so the witnesses don't think I'm picking on them, now you can listen to what I'm about to tell counsel on behalf of the Board. We've seen cross-examination that's been excellent,

we've seen cross-examination that's not been good. We've seen everything in between. I think there's some steps we can take that will move things along. You learned your first day of trial procedure in law school, don't have cross-examination just be a repeat of the direct. The person has put in their written testimony, why give them a chance to say it again orally. We don't need it. Don't use cross-examination to educate yourself about the case. Use cross-examination to try to prove your opponent's case is not well taken. In doing that, there are no -- essentially no requirements that you lay a foundation. You can ask the opponent's witness on cross-examination any question you want. Isn't it true that such and such? There's not a valid objection to that question that such-and-such has not been proven in the record. You may ask the question directly. Don't beat around the bush. If you have something to ask the witness, you think something they're weak on, ask them the question. Ask them what they think now, not what they said in their deposition. We don't care what they said in their deposition. We want to know what they think now. Now, if what they say now is different from what they said in their deposition, then go after

them, ask them why they changed their minds. But let's talk about what witnesses believe now, not what they believed six years ago or two months ago. Unless you need to use that for impeachment.

We've seen in cross-examination, points of diminishing return, where cross-examination starts out well with the witness and you get to a certain point and then there's just more questions that really aren't getting somewhere. Of course you don't know what's in our mind, but where we think you've reached the end of the line, we'll say, you know, if there's nothing more here, let's move on. If you really think there is more there, tell us, but you only get a few chances and you better be right.

At some point, if things really bog down, as Licensing Boards have done in the past, we've put you on the clock. We'll say, okay, you've got 15 more minutes on this subject. You can ask any questions you want, but at the end of the 15 minutes, we're moving on.

We will attempt to ask our questions, where we're trying to make sure we understand the record, we will try to ask those at the end of the last cross-examination, so that when the sponsor of

the witness gets to redirect, they have -- they know what their opponent's have had on their minds and they know what our questions will be, so that will shorten how many redirects and recrosses you have to do.

I think if we follow all these rules, we have a chance of -- and again, we want to be efficient, but we said on the very first day and we still believe we want to be fair, these are important issues to your clients, these are important issues to the citizens of Utah. They are important issues for the United States, and we want to make sure that we're fair, but sometimes fairness is better obtained by precision rather than imprecision.

You all have used sports analogies. Mr. Turk referred to a marathon, Ms. Chancellor was looking for the home court advantage, which is very timely given tonight's game. I'm going to use a golf analogy. Those of you who play golf know you like to play with a foursome. And let's take the average player who shoots 90. That's 360 shots in the course of a foursome playing a round of golf. And I know some of them are puts, but disregard that for a moment. A round of golf should take

four hours. If each time a player is supposed to hit, he or she is not ready, hasn't checked the wind, hasn't figured out the club, hasn't done the distance analysis while the other players were hitting, if each player takes 10 seconds that he shouldn't have taken, he or she shouldn't have taken, that's 3600 seconds added to the round. That's an hour. A four-hour round becomes a five-hour round just from a lot of little bits of wasted time. That means if you have a five-day hearing, you've wasted one of those days. So let's bear this in mind in terms of being organized and being precise, of being ready, of asking questions that matter, not questions that don't matter.

It's now 10:00. An hour of today is gone. I hope in light of the seriousness of both the arguments about where the hearing should be held and the admonitions we've just given witnesses and counsel, we can now proceed to best advantage.

JUDGE LAM: If we all practice what Judge Farrar said, we'd all be Jack Nicholas in two weeks and go home. That's what I hope.

MR. GAUKLER: Are you ready to call my panel, the first witnesses?

JUDGE FARRAR: Yes, unless anyone needs

a break, let's press right on and get your panel sworn, Mr. Gaukler.

MR. GAUKLER: Your Honor, I'm going to hand out a copy of our exhibits. We have all the PFS prefiled exhibits in one book and I thought that would be most handy to give everyone a book and they can just look at that, a tab, et cetera. We'll introduce them as we go through the witnesses. But we better get all the prefiled exhibits right now so you can keep that book handy throughout our witnesses, that will help.

JUDGE FARRAR: That is very helpful, Mr. Gaukler. And that reminds me of one thing. If all counsel will, when they're questioning the witness, up-front refer them to any document that you're questioning them about. We had this last week with the FEIS, and the State was very good, they did what you did, they handed out a book of exhibits, and Mr. Nelson, every time he asked a question, referred the witness to the exhibit and the page he was talking about. That helped the court reporter, that helped the witnesses, it helped us, and it saved great amounts of time with everyone fumbling around trying to put the right document in their hands.

MR. GAUKLER: I've given three copies of the testimony to the reporter. Do you have your copies from before?

JUDGE FARRAR: Are these the same as you've previously submitted?

MR. GAUKLER: Yes, with a few corrections the witnesses will make on the record.

JUDGE FARRAR: Let's do this procedural matter off the record.

(A discussion was held off the record.)

JUDGE FARRAR: We're back on the record, having dealt with the exhibits.

MS. CHANCELLOR: Your Honor, could I ask Mr. Gaukler if the exhibit book he passed out is exactly the same as the exhibits you filed?

MR. GAUKLER: Excuse me, what was that, Ms. Chancellor?

MS. CHANCELLOR: Is the exhibit book you passed out exactly the same as the exhibits you filed?

MR. GAUKLER: There is -- with respect to Exhibit MM, there was some additional materials at the end of that exhibit which we removed from the book that we just passed out.

JUDGE FARRAR: You'll explain that as we

get to it?

MR. GAUKLER: Yes.

JUDGE FARRAR: Thank you.

Mr. Gaukler, should I swear in your witnesses?

MR. GAUKLER: Yes.

JUDGE FARRAR: Would you gentlemen stand and raise your right hand, please.

ROBERT R. YOUNGS, WEN SHOU TSENG,

called as witnesses for and on behalf of the Applicant, being first duly sworn, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. GAULKER:

Q. Would you please state your names for the record.

DR. YOUNGS: Robert Riggs Youngs, spelled R-I-G-G-S.

DR. TSENG: Wen Shou Tseng.

Q. Dr. Youngs and Dr. Tseng, do you have a copy of your testimony entitled Joint Testimony of Robert Youngs and Wen Tseng on Unified Contention Utah L/QQ, dated April 1, 2002 in front of you?

DR. YOUNGS: I do.

DR. TSENG: I do.

Q. Now, is this testimony prepared by you or under your supervision and direction?

DR. YOUNGS: Yes, it is.

DR. TSENG: Yes, it is.

Q. Do you have any corrections to make to this testimony?

DR. YOUNGS: I have two minor typos on Page 8. The second-to-the-last line of Answer 23, the word that, should be the word than, the fourth word in the sentence. And on page nine, in the first paragraph, next-to-the-last line, Alan Soler should be A-L-A-N. That's all I have.

DR. TSENG: I also have three corrections in the nature of typos. The first one is on Page 10, answer, the first line of answer to Question 27, Figure 4.2-7 will be changed to Figure 1.2-1. On Page 16, Question 50, the first line, there are two that that. One of the that should be crossed out. And then on Page 23, Question 69, the first line after table 5.2.5-1, the few words, at Page 214, the at page 214 will be crossed out. And that's all.

Q. With these changes, do you accept and

adopt this testimony as true and correct and as your testimony in this proceeding?

DR. YOUNGS: I do.

DR. TSENG: I do.

MR. GAUKLER: Your Honor, we would also like to move into evidence.

JUDGE FARRAR: You want this testimony --

MR. GAUKLER: Included in the record.

JUDGE FARRAR: We'll include it, bind it in the record at this point as if read. I'm sorry, any objection?

MS. NAKAHARA: No objection.

MR. TURK: No, Your Honor.

JUDGE FARRAR: Then we'll do that.

(Prefiled testimony of Robert R. Youngs and Wen S. Tseng follows:)

April 1, 2002

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

JOINT TESTIMONY OF ROBERT YOUNGS AND WEN TSENG ON UNIFIED CONTENTION UTAH L/QQ

I. WITNESSES

A. Robert R. Youngs ("RY")

Q1. Please state your full name.

A1. Robert R. Youngs.

Q2. By whom are you employed and what is your position?

A2. (RY) I am a Principal Engineer employed by Geomatrix Consultants Inc., in Oakland, California.

Q3. Please summarize your educational and professional qualifications.

A3. (RY) My professional and educational experience is summarized in the curriculum vitae attached to this joint testimony. I have over 25 years of professional consulting experience, primarily focused in the analysis of seismic hazards. My experience encompasses, among other areas, the characterization of earthquake ground motions and the performance of probabilistic and deterministic analyses to develop seismic design criteria for ground motion and fault

displacement. I have conducted these types of analyses for seven NRC-regulated nuclear power plants located in the Western United States. I have also performed similar studies for nuclear power plants in Canada, Spain, Slovakia, and Bulgaria, and am currently involved in similar studies for nuclear power plants in Switzerland and Slovenia. In addition, I have performed similar studies for existing and proposed Department of Energy ("DOE") nuclear facilities at Hanford, Washington; INEEL, Idaho; Rocky Flats, Colorado; Savannah River, South Carolina; and Yucca Mountain, Nevada.

Q4. Are you familiar with the Private Fuel Storage Facility ("PFSF") and the activities that will take place there?

A4. (RY) Yes.

Q5. What is the basis of your familiarity with the PFSF?

A5. (RY) I was part of a Geomatrix team that performed the seismic hazard analysis for the PFSF. I was one of the authors of the Geomatrix Report, "Fault Evaluation Study and Seismic Hazard Assessment, Private Fuel Storage Facility." I was specifically responsible for conducting the probabilistic seismic hazard analysis and developing the design basis ground motions for the PFSF from the results. I was also responsible for developing a set of "time histories" to represent the design basis ground motions, and for developing dynamic soil properties for use in the dynamic analyses of the storage cask pads and the Canister Transfer Building ("CTB") at the PFSF. I have also reviewed Unified Contention Utah L/QQ, in which the State of Utah raises various challenges to the seismic analysis for the PFSF site, and related materials.

B. Wen Shou Tseng ("WT")

Q6. Please state your full name.

A6. Wen Shou Tseng.

Q7. By whom are you employed and what is your position?

A7. (WT) I am President of International Civil Engineering Consultants, Inc. ("ICEC"). ICEC is a company that provides specialty consulting services in the general areas of civil and structural engineering with special emphasis on earthquake engineering. As President of ICEC, I am responsible for all aspects of the company operation including technical, administrative, financial, contractual and business development matters.

Q8. Please summarize your educational and professional qualifications.

A8. (WT) My professional and educational experience is described in the *curriculum vitae* attached to this joint testimony. I have been doing research and development, and performing consulting services in the general areas of civil and structural engineering, for more than 30 years. My area of specialization is earthquake engineering with special emphasis on the evaluation of soil-structure interaction effects on structures. I have published many technical papers and technical and project reports on soil-structure interaction subjects.

Q9. What is your experience with nuclear facilities and the NRC's requirements for the design and licensing of dry cask storage systems?

A9. (WT) ICEC has performed work for numerous nuclear facilities, in which I have been personally involved. While at ICEC in the last 12 years, we have performed consulting work on seismic analyses, including analyses for soil-structure interaction, for TVA's Browns Ferry and Bellefonte Nuclear Power Plants, PG&E's Diablo Canyon Nuclear Power Plant, and Taiwan Power Company's Fourth Nuclear Power Plant in Taiwan. Further, during my last 12 years at Bechtel prior to joining ICEC, I was head of Bechtel's Special Structures Group performing research and development and providing technical consulting services to many nuclear power generating facilities, including the Susquehanna, Limerick, Pilgrim II, Hope Creek, Skagit, Trojan, Tsuruga II, Sequoyah, Browns Ferry, Watts Bar, Bellefonte, and Diablo Canyon nuclear power plants. The work on all these plants involved elements of seismic analysis and design of the plant structures, systems and components, including soil-structure interaction.

Q10. Are you familiar with the PFSF and the activities that will take place there?

A10. (WT) Yes.

Q11. What is the basis of your familiarity with the PFSF?

A11. (WT) ICEC is the designer of the reinforced-concrete storage pads to be constructed at the PFSF site on which the HI-STORM 100 storage casks will be placed. In that capacity, ICEC performed the necessary analyses to support the design of the PFSF reinforced-concrete storage pads. ICEC has already designed the pads based on the design calculations. The storage pad, as designed, is a 30-ft. wide, 67-ft. long and 3-ft. thick reinforced concrete pad supported directly on cement-treated soil to be installed at the site. I was the independent reviewer for the ICEC design calculation for the storage pads. As independent reviewer, I was responsible for assuring the technical adequacy of the design calculations and the design. This independent review was made to satisfy quality assurance ("QA") requirements of ICEC for nuclear projects, as specified in ICEC's Quality Assurance Manual for Nuclear Projects.

Based on this experience and my general oversight function of ICEC's activities for the PFSF project over the past several years, I am familiar with the site-specific soil characteristics, design seismic ground motions, and other project design requirements, as specified in the PSFS project's design criteria document. I have also reviewed Unified Contention Utah L/QQ, in which the State of Utah raises various challenges to the seismic analysis for the PFSF, and related materials.

II. RELEVANT PFSF DESIGN AND DESIGN PARAMETERS

A. Design Basis Parameters Developed by Geomatrix for PFSF Design

Q12. Dr. Youngs, please describe the design basis ground motions developed by Geomatrix for the design of the PFSF.

A12. (RY) The design basis ground motions for the PFSF are those for the probabilistic 2000-year return period earthquake for the PFSF site. These motions are represented by a horizontal peak ground acceleration of 0.711g, a vertical

peak ground acceleration of 0.695g, and associated response spectra corresponding to motions at the ground surface in the free field. These ground motions for the design of the PFSF were developed based on the characterization of potential sources of future earthquakes and the characterization of the expected response of the underlying soils, including a surface soil cement layer, to earthquake motions.

Q13. What other related design information did Geomatrix develop as part of its work for the PFSF?

A13. (RY) Geomatrix developed (1) the lower range, best estimate, and upper range soil properties to be used in dynamic analyses for the CTB and the storage pads; (2) the soil mass, soil spring, and soil damping values to be use for dynamic analyses of the storage pads; and (3) the time histories to be used for these analyses. Items (1) and (2) incorporated the presence of the surface soil cement layer.

Q14. What nuclear codes and standards did Geomatrix use in its development of the above design parameters?

A14. (RY) The probabilistic seismic hazard analysis ("PSHA") conducted for the site followed the general provisions for such an analysis presented in Regulatory Guide 1.165. The procedures outlined in Appendix C of Regulatory Guide 1.165 were used to develop the design earthquake response spectra from the results of the probabilistic seismic hazard analysis. The three-component set of time histories was developed to meet the requirements specified in Section 3.7.1.2 of the NRC's Standard Review Plan (NUREG 0800). Dynamic soil properties were developed for the site incorporating the uncertainty ranges recommended in Section 3.7.2 of NUREG 0800 and in the American Society of Civil Engineers Standard ASCE 4-86 for the seismic analysis of safety-related nuclear structures.

Q15. Are these the same codes and standards that one would follow for developing the design of nuclear power plants?

A15. (RY) Yes.

Q16. Did you apply the relevant provisions of these codes or standards in developing the above design information for the PFSF the same way you would have for a nuclear power plant?

A16. (RY) Yes, with the exception that the reference probability used for establishing the design ground motions for the PFSF is not the same as that specified for a nuclear power plant.

Q17. Please identify the soil properties for which Geomatrix developed best, lower and upper range estimates for use in the design of the PFSF.

A17. (RY) The dynamic soil properties developed for PFSF represent the stiffness, mass, and energy dissipation characteristics (damping) of the foundation soils during the design earthquake shaking condition. Two types of soil properties were developed. The seismic response analyses of the CTB were performed using an approach, in which the underlying soil medium is represented by a continuum. For this analysis Geomatrix developed three (layered) models of the site in which the soil stiffness is represented by the compression wave velocity and strain-compatible shear wave velocity of each soil layer, the soil mass is represented by the density of each layer, and the soil damping is represented by the strain-compatible damping ratio for each layer. These three models consist of a lower range estimate, a best estimate, and an upper range estimate. The dynamic analysis of the response of the storage cask pads and storage casks used a lumped-parameter approach in which the dynamic impedance characteristics of the underlying soil medium are represented by lumped soil mass, soil spring, and soil damping (dash-pot) values. For this approach, three sets of soil-springs, soil-masses, and soil dash-pots were developed. These three sets consist again of a lower range estimate, a best estimate, and an upper range estimate.

Q18. Why were two different methods used to develop soil properties for CTB and for the cask storage pads and casks?

A18. (RY, WT) The choice of two different methods of analysis is a matter of convenience and/or necessity, considering the specific design purpose and requirements. Either method will give valid results when properly utilized. For the CTB, which is essentially a linear system, only linear seismic responses are to

be computed, thus representing the foundation soil medium as a continuum and producing a set of frequency-dependent foundation impedance functions is convenient, since the analysis lends itself to a frequency-domain seismic response method. To calculate the seismic response of the free-standing storage casks, which involves nonlinear sliding and rocking responses, a nonlinear time-history response analysis is required. For the cask and pad case, representation of the dynamic characteristics of the foundation soil medium must be provided, represented by frequency-independent lumped parameters that are invariant with respect to time. Therefore, a lumped-parameter approach was adopted for the cask and pad seismic response analysis.

Q19. Why does one need to develop lower and upper range estimates of these soil properties in addition to a best estimate?

A19. (RY, WT) The development of lower and upper range estimates of these soil properties in addition to a best estimate is intended to account both for variations in the soil material properties at the site and for other seismic modelling uncertainties that are difficult to quantify, as discussed in ASCE Standard 4-86 to which the PFSF project has committed.

Q20. How did Geomatrix develop the "best estimate" and the lower and upper range estimates of the soil properties for use in design of the PFSF?

A20. (RY) The best estimate soil properties were developed by first calculating the average seismic wave velocities in the subsurface soils using the data collected from wave velocity measurements at the site. The shear wave velocity and damping in soils is dependent upon the level of shaking, with the shear wave velocity decreasing and the damping increasing as the level of shaking increases. Site response analyses were conducted using the design time histories to obtain the shear wave velocities and damping ratios representative of the design earthquake shaking levels. These are termed "strain-compatible" soil properties. Upper and lower range soil properties were obtained by varying the best estimate soil properties following the guidelines given in the NUREG 0800 and ASCE 4-86. Site response analyses where then conducted using the design time histories

to obtain the strain-compatible shear wave velocities and damping ratios for the upper and lower range soil-property profiles representative of the design earthquake shaking levels.

Q21. What was the range of these soil property parameters as developed by Geomatrix?

A21. (RY) The low strain shear moduli were varied by a factor of 1.5 down to a depth of 30 feet and, varied by a factor of 2 for depths below 30 ft.

Q22. Please describe what time histories represent and how they are used in the seismic design of structures and components.

A22. (RY) Time histories represent the variation of ground acceleration with time during an earthquake. They are used to represent the motions to which the site structures would be subject during the design earthquake.

Q23. Please describe the time histories that Geomatrix developed for the PFSF.

A23. (RY) Geomatrix provided a set of time histories for the 2000 year design basis earthquake for the PFSF site showing the earthquake accelerations in the two horizontal directions (generally referred to as the x and y coordinates) and the vertical direction (generally referred to as the z coordinate). For the PFSF site, the x direction represents east-west motion, which is normal to the faults that are the primary source of earthquake hazards to the site. The y-direction represents north-south motion, which is parallel to these faults. It has been shown that for low frequency motions (generally 1 Hz or less) the fault-normal component of motion is larger than the fault-parallel component, especially when the site is near the causative fault.

Q24. What methodology did you generally follow in developing this set of time histories for use in the PFSF design?

A24. (RY) NUREG 0800 describes two approaches for developing design time histories. One approach is to use multiple sets of time histories that in the aggregate envelop the design response spectra, although any individual time history may fall well below the design spectrum at some frequencies. The second approach is to develop a single set of time histories that envelops the design

response spectra. Time histories developed using the second approach are often called spectrum-compatible time histories. The spectrum-compatible approach was appropriate for use to develop the set of time histories for the 2,000-year design earthquake for the PFSF for the reasons explained in the testimony of Krishn P. Singh and Alan Soler of Holtec, International being filed simultaneously.

Q25. Please describe generally how you developed the set of time histories for use in the PFSF design using the spectrum compatible approach.

A25. (RY) The first step was to select an earthquake recording that is representative of the type of earthquakes contributing to the seismic hazard at the PFSF site. The Sturno recording of the November 23, 1980 **M** 6.9 Irpinia, Italy normal-faulting earthquake was selected. The Sturno site was located approximately 11 km from the northwest end of the fault rupture in the hanging wall block (above the fault), which is generally consistent with the relationship of the PFSF site to the Stansbury fault, the main source of seismic hazard to the PFSF site. The Sturno recording shows evidence of a velocity pulse representative of near-fault effects observed in a number of strong motion recordings. The two horizontal components of motion were rotated into fault-normal and fault-parallel directions. The three components of motion (fault-normal, fault-parallel, and vertical) were then modified until their resulting response spectra enveloped the design response spectra following the criteria specified in NUREG 0800.

B. ICEC Design and Analysis of the PFSF Storage Pads

Q26. Dr. Tseng, please describe the PFSF storage cask pads for which ICEC provided the design.

A26. (WT) The storage cask pads will be independent structural units constructed of reinforced concrete supported directly on cement-treated soil at the site. Each pad will be 30 ft wide, 67 ft long and 3 ft thick and will be capable of supporting eight loaded HI-STORM 100 storage casks. Each pad is designed to accommodate a 2 x 4 array of casks with a 15 ft pitch in the width direction and 16 ft in the length direction.

Q27. Would you please describe the number and relative location of the storage pads to be located at the PFSF?

A27. (WT) The layout of the storage pads is shown in Figure ~~4.2-7~~ 1.2-1 of the PFSF Safety Analysis Report ("SAR"). At maximum capacity of the PFSF, there would be 500 cask storage pads designed as I described above. The storage pads will be constructed in a regular array with five ft. of spacing between adjacent pads in the longitudinal direction and 35 ft. spacing between adjacent pads in the lateral direction.

Q28. Please describe generally the process by which ICEC went about the design and analysis of the PFSF storage cask pads.

A28. (WT) The initial layout dimensions of the storage pads was provided to ICEC. ICEC then prepared a static and dynamic model of the pad/soil system and performed analyses of the pad/soil system under static and dynamic loading conditions to determine the internal stresses in the storage pad. Holtec provided the cask dynamic response forcing functions at the cask/pad interface boundaries, which were used in ICEC's pad dynamic analyses. The internal stresses calculated in the ICEC analysis were then used to determine the amount of reinforcing steel bars required for the reinforced concrete pad to resist the combined stresses in accordance with the project design criteria.

Q29. What was the purpose of the calculation that ICEC prepared for the design of the storage cask pads?

A29. (WT) The purpose of ICEC's design calculation was to determine the internal stresses induced in the storage pad when subjected to the design loading conditions and to check the ability of the pad as designed to resist the stresses caused by the specified loading conditions. The internal stresses determined from the design calculation were then used for establishing the amount of steel reinforcement required in order for the pad to resist the applied loading conditions. Since the design calculation is used to determine internal stresses under design loadings, the pad itself was modelled as a flexible pad supported on

flexible soil foundations using a finite-element model for the pad and soil spring representation for the soil foundation.

Q30. What nuclear codes and standards did ICEC follow in its design and analysis of the storage pads?

A30. (WT) The codes and standards used in design and analysis of the storage pad are (1) American Concrete Institute ACI 349-85 (1990), "Code Requirements for Nuclear Safety Related Concrete Structures" and (2) American Society of Civil Engineers, ASCE Standard 4-86, "Seismic Analysis of Safety Related Nuclear Structures and Commentary." The seismic soil-structure interaction analyses of the pad/soil system also followed the guidelines recommended in the NRC Standard Review Plan for nuclear power plants, NUREG-0800.

Q31. Are these the same codes and standards that one would follow for the design and analysis of similar structures for nuclear power plants?

A31. (WT) Yes.

Q32. Did ICEC apply the applicable requirements of these codes or standards in its design and analysis of the pads the same as it would have for a nuclear power plant?

A32. (WT) Yes.

Q33. Are there conservatisms embodied in the codes and standards as ICEC applied them in its design and analysis of the storage pads for the PFSF?

A33. (WT) Yes.

Q34. Please describe these conservatisms?

A34. (WT) As with all codes and standards, conservatism exists in specification of load factors, load combinations, and allowable material strengths to be used for the design. Additional conservatism exists in using large variations (a factor of 1.5 to 2 variations) of soil properties in the analyses and using the results enveloped from the lower range, best estimate, and upper range soil cases for design.

III. RESPONSE TO THE STATE OF UTAH'S CLAIMS IN SECTION D

A. Overview of Testimony

Q35. The State of Utah has raised several claims in Section D of Unified Contention Utah L/QQ ("Unified Contention"). Which of those claims will you be addressing in your testimony?

A35. (RY, WT) We will be addressing in whole or in part issues related to (1) the claims raised in Section D.1.a of the Unified Contention concerning non-vertically propagating waves, (2) the claims raised in Section D.1.b of the Unified Contention concerning pad rigidity, (3) the claims raised in Section D.1.c of the Unified concerning the evaluation of pad and cask sliding, (4) the claims raised in Section D.1.d of the Unified Contention concerning lateral variations in ground motion phase, (5) the claims raised in Section D.1.e of the Unified Contention concerning the frequency dependency of soil springs and damping values, and (6) the claims raised in Section D.1.h of the Unified Contention concerning the use of multiple time histories.

Q36. In general, what is your response to these claims raised by the State?

A36. (RY, WT) After review of the claims and examination of certain additional calculations made to evaluate some of the claims, we have concluded that, even if the claims raised by the State were incorporated, the resulting variations in the results of the analyses used for the design, would be inconsequential and would not affect the adequacy of the final design.

B. Specific Responses to The State of Utah's Claims Raised in Section D of the Unified Contention Utah L/QQ

1. Claims Raised in Section D.1.a of Unified Contention – Non-Vertically Propagating Seismic Waves

Q37. Please describe the claim raised by the State in Section D.1.a of the Unified Contention.

A37. (RY, WT) In Section D.1.a of the Unified Contention, the State claims that "Applicant's calculations unconservatively assume that only vertically propagating in-phase waves will strike the pads, casks and foundations, and fail to

account for horizontal variation of ground motion that will cause additional rocking and torsional motion in the casks, pads and foundations." The State claims that because of the location of the PFSF site near active faults, non-vertically propagating waves with large angles of incidence capable of causing additional rocking and torsional motion may impinge the pad, casks and foundations.

Q38. Do you agree that PFSF's location near active faults is more likely to produce nonvertically propagating seismic wave with large angles of incidence.

A38. No. PFSF's proximity to two active faults does not make it more likely that the incoming waves will have high angles of incidence.

Q39. What is your response to the claims raised by the State in Section D.1.a?

A39. (RY, WT) Based on our evaluation, we have concluded that the angles at which seismic waves would impinge the PFSF site are small (generally less than 10 degrees from vertical), and the waves can, for all practical purposes, be considered to be vertical. The rocking and torsional motions of the storage pads caused by the small angles of incidence from vertical of the seismic waves arriving at the PFSF site would be insignificant.

Q40. Dr. Youngs, please describe the analyses upon which you base your conclusion.

A40. (RY) Employing standard methodologies, I calculated the angle of incidence of the earthquake waves impinging the PFSF site originating from the primary sources of earthquake hazards to the PFSF, the Stansbury and East faults. I determined that the angle of incidence would be very close to vertical, typically less than 10 degrees for the frequencies of interest. Thus, the proximity of the site to the major active faults does not result in high angles of incidence from vertical for earthquake waves impinging the sites and the assumption of vertically propagating waves is reasonable for the site. This evaluation is set forth in the March 11, 2002 Geomatrix Evaluation of Spatial and Temporal Variation of Ground Motion for the Private Fuel Storage Facility, Skull Valley, Utah ("Geomatrix Evaluation") pages 1-4, identified as PFS Exhibit LL.

Q41. The State's witness Dr. Ostadan testified in his deposition that there are no standard or accepted methodologies for calculating the angle of incidence of earthquake waves. Do you agree with that statement?

A41. (RY) No. The method of ray tracing that I used is described in standard seismology textbooks, such as K Aki and P.G. Richards (1980) Quantative Seismology W.H. Freeman & Co., San Francisco. I confirmed, through discussions with a knowledgeable seismologist, Dr. Walter Silva of Pacific Engineering and Analysis, that the travel path of seismic waves can be readily calculated by what is termed "ray tracing."

Q42. Please describe the methodologies that you used to calculate the angle of incidence and state on what basis you conclude that you employed standard methodologies.

A42. (RY) The direct ray path of a body wave (such as the shear waves of primary interest to the shaking hazard from nearby fault ruptures) from a point source at depth to a point on the surface has two properties. The first is that it represents the minimum travel time path between the two points. The second is that the ray path obeys Snell's law at all layer boundaries such that the ratio of the sine of the angle of incidence (measured from the normal to the layered boundary) to the layer velocity is constant along the ray path ($\sin(i_i)/V_i$=constant). Using these properties, I performed two separate calculations. In the first, I solved iteratively for the minimum travel time path between two points without imposing Snell's law at the layer boundaries in the Skull Valley velocity model. In the second, I imposed Snell's law along the travel path and solved iteratively for the ray angle at the source that resulted in a ray path that reached the surface at the designated site. These two algorithms produced the same travel path. As a further check, I asked Dr. Walter Silva to perform several test calculations using his ray tracing computer program. His results agreed with those that I obtained.

Q43. Dr. Youngs, you referred to the frequencies of interest in your answer to an earlier question. What is meant by frequencies of interest?

A43. (RY) The frequencies of interest for the case of casks supported on pads are the dominant frequencies of the cask response motions, when the casks are undergoing their largest amplitude of dynamic response.

Q44. How did Geomatrix go about determining the frequencies of interest in its March 11, 2002 evaluation?

A44. (RY) As explained in Section C of the March 11, 2002 Geomatrix Evaluation (PFS Exhibit LL), Geomatrix requested and received from Holtec dynamic response time histories obtained at the top of the HI-STORM System casks for the "worst case" evaluations done by Holtec as part of its cask stability analysis for the PFSF 2000 year design basis earthquake. These response time histories (attached as Appendix A to the March 11, 2002 Geomatrix Evaluation) represent movement of the casks in response to the earthquake time histories that Geomatrix provided to Holtec for its analysis of the casks. These response time histories indicate that the largest cask movements occur principally in the time interval 4 to 7 seconds after initiation of the event, as shown in the design time histories. We computed the Fourier spectrum for that portion of the top-of-cask time history and the Fourier spectrum for the same time window of the input time histories that produces the cask response. The peaks in the ratio of these two spectra indicate the predominant frequencies of the cask's response to the input motion. The peak response of the cask occurred in the frequency range of 1 to 5 Hz.

Q45. Dr. Tseng, did you review Geomatrix's determination of the frequencies of peak cask response?

A45. (WT) Yes, I did. Geomatrix used a standard methodology for determining the dominant response frequency of a structure. I have reviewed Geomatrix's calculation results obtained by application of this methodology to the response time histories received form Holtec and agree that the peak cask response frequency range is between 1 and 5 Hz.

Q46. Dr. Youngs, to recapitulate, you calculated the angle of incidence of the earthquake waves for the frequencies for which peak cask response would be observed?

A46. (RY) Yes, the angle of incidence is generally less than 10 degrees off vertical for all frequencies in the 1-5 Hz range, the frequency range of peak cask response.

Q47. What else was done to evaluate the claims raised by the State in Section D.1.a of the Unified Contention?

A47. (RY, WT) Geomatrix evaluated the potential effects of the small departure from vertical of the angle of incidence of the earthquake waves impinging the PFSF site.

Q48. What effect would one expect and why?

A48. (WT) Because of the small departure of the angle of incidence from vertical and the small size of the pads (30 by 67 ft in plan dimensions), one would expect that this slight departure from vertical would cause only very minor effects on the pad response. The results of the Geomatrix evaluation confirm that the small departure in the angle of incidence from vertical causes negligible effects on the response motion of the storage pads.

Q49. Dr. Tseng, have you reviewed this evaluation done by Geomatrix?

A49. (WT) Yes.

Q50. And do you agree that ~~that~~ the effects of the small departure in the angle of incidence from vertical, as shown by Geomatrix, are negligible for the storage pads?

A50. (WT) Yes.

Q51. Please describe the evaluation done by Geomatrix of the potential effects of the small variance of the angle of incidence from vertical of the earthquake waves impinging the PFSF site.

A51. (RY) First, one can evaluate the potential effect of inclined waves on the storage pads by calculating the difference in arrival times at two adjacent points on the pads. The storage pads have a width of 30 ft. in the east-west direction, which is also the fault normal direction. The primary faults are oriented in an approximately north-south direction. Therefore, for nearby ruptures of the Stansbury fault, the strongest shaking will be due to earthquake waves arriving

from the east. Calculating the difference in the arrival times of earthquake waves at the east and west edges of the pads for the small angle of incidences determined by Geomatrix, one obtains differences in arrival times on the order of 0.001 to 0.002 seconds. These time differences would only affect motions in very high frequency, higher than about 50 to 100 Hz, which are far above the dominant frequency range of peak cask response of 1 to 5 Hz.

Q52. Please explain why a time difference in arrival of earthquake waves on the east and west edges of the pads on the order of 0.001 to 0.002 seconds would not be of significance.

A52. (RY, WT) A seismic wave generally requires a minimum of 10 equal time steps to define it. A time lag of the order of 0.001 to 0.002 seconds will start to affect a seismic wave having a period of 0.01 to 0.02 seconds. The inverse of the period of a wave is the frequency of the wave. Thus, the seismic waves that will be affected by a time lag of the order of 0.001 to 0.002 seconds will be those having their frequencies higher than 50 Hz (= 1/0.02 seconds) to 100 Hz (= 1/0.01 seconds). Such high-frequency waves are beyond the frequency range that are generally of interest for seismic design, which is normally below 50 Hz, and are far below the dominant frequency range of peak cask response of 1 to 5 Hz.

Q53. What else did Geomatrix do to evaluate the potential effects of the small departure of the angle of incidence from vertical of the earthquake waves impinging the PFSF site?

A53. (RY, WT) Geomatrix also evaluated the effects of low incident angle waves on the pad response using published work of Luco (1976) and Wong and Luco (1978).

Q54. Please describe the nature of this evaluation.

A54. (RY, WT) In the near field there are two major types of seismic waves that are responsible for strong ground shaking, compression waves (P-waves) and shear waves (S-waves). Compression waves represent push-pull motion in the direction of propagation and are analogous to sound waves in air. Shear waves represent side-to-side motion at right angles to the direction of wave propagation (shearing). This side-to-side motion occurs in two planes. Side-to-side motion in the

horizontal plane is denoted by SH-waves and side-to-side motion in the vertical plane is denoted by SV-waves.

When seismic waves strike a structure at an angle of incidence (from vertical) greater than 0 they can induce additional components of motion beyond horizontal and vertical translation (side-to-side and up-and-down motions). Inclined SH-waves tend to induce torsional motions (rotation about a vertical axis) and inclined P and SV waves tend to introduce rocking motions (rotation about a horizontal axis). The amount of this additional motion depends on the angle of incidence and the dimensions of the structure. Studies by Luco (1976) and Wong and Luco (1978) provide evaluations of the amount of this additional motion as a function of two dimensionless parameters. The first is the normalized frequency of the foundation and represents the ratio of the foundation dimension to the wave velocity in the underlying material. The second is the ratio of the wave velocity in the underlying material to the apparent wave-passage velocity and is equivalent to the sine of the angle of incidence.

Luco's 1976 work studied the effects of obliquely incident SH-waves on the torsional response of foundations. For the frequency range of 1 to 5 Hz, Geomatrix estimated the maximum angles of incidence to be 11° for 1-Hz waves and 3° for 5-Hz waves. Based on the results published in Luco's 1976 paper, Geomatrix concluded that these angles of incidence would induce a very small amount of additional torsional response of the pads, on the order of 1 to 3 percent of the amplitude of the direct horizontal translational motion.

The work published in Wong and Luco's 1978 paper addresses the rocking motion induced by inclined SV- and P-waves. Based on this work, Geomatrix concluded that for the frequency range of 1 to 5 Hz, the angles of incidence of 3° to 11° would induce rocking motion on the order of 5 percent of the direct vertical motion amplitude.

Q55. What conclusions can be drawn from these various analyses of the potential effects of the small departure from vertical of the angle of incidence of the earthquake waves impinging the PFSF site?

A55. (RY, WT) These analyses show that the additional rocking and torsional motion of the pad caused by inclined incident waves at the PFSF would be small compared to the motion caused by the vertically propagating waves. The calculations presented by Holtec show that there are very large margins in the range of cask movements calculated for the design earthquakes. Any small additional motion induces by inclined waves would be insignificant compared to these margins.

Q56. How do the effects of non-vertically propagating waves at the PFSF site discussed above relate to the conservatisms embodied in the ASCE Standard 4-86?

A56. (WT) As discussed in the ASCE Standard 4-86, Section 3.3.1.7, there are various uncertainties in modeling and analysis of soil-structure interaction effects. The variation of soil properties from the best-estimate values to their lower-range and upper-range values is a means intended to account for many such uncertainties. A conservative variation of soil moduli by a factor of 1.5 to two for the lower and upper ranges was used for the PFSF which provides a way to account for uncertainties.

Q57. What conclusions do you draw based on your evaluation of the State's claims in Section D.1.a of the Unified Contention?

A57. (RY, WT) With the small angles of incidence (off vertical) of the seismic waves that may potentially occur at the site, and within the dominant frequency range of interest for the cask response, the effect of earthquake motions on structures and components at the PFSF may be represented by the use of vertically propagating earthquake waves, and the effect of non-vertically propagating waves alleged by the State is insignificant.

2. Pad Rigidity Claims Raised in Section D.1.b of Unified Contention

Q58. Please describe the claim raised by the State in Section D.1.b of the Unified Contention.

A58. (WT) In Section D.1.b of the Unified Contention, the State claims that calculations done by the Applicant incorrectly assume that the pads will behave rigidly during the design basis earthquake and that this assumption of rigidity leads (i) to "[s]ignificant underestimation of the dynamic loading atop the pads, especially in the vertical direction," and (ii) to "[o]verestimation of foundation damping."

Q59. What calculations is the State referring to in its claims raised in this Section of the Unified Contention?

A59. (WT) The State is referring to two calculations, the first performed by Stone & Webster of the stability of the storage pads and the second performed by Holtec of the stability of the casks on the storage pads. The Stone & Webster Calculation 05996.02-G(B)-04, Rev. 9, Stability Analyses of Cask Storage Pads (July 26, 2001) analyzes three potential failure modes for the pads, sliding, overturning, and bearing capacity failure. The Holtec calculation assesses the earthquake loads of the casks imposed on the pads as well as the stability of the Holtec casks under design basis earthquake loads. As described in Dr. Ostadan's deposition, the State's claims of pad flexibility affect the two calculations differently. See Ostadan Dep. at 82-84, 109-120.

Q60. Please describe the claims raised by the State with respect to the Holtec calculation?

A60. (WT) The claims concern Holtec's assumption that the concrete storage cask pads are rigid and the effect that this allegedly erroneous assumption has on the calculation of the soil spring and dash pots as related to foundation damping. See Ostadan Dep. at 109-115. The State claims that as a result of this erroneous assumption Holtec underestimates the loads on the pads and overestimates foundation damping. See Ostadan Dep. at 105-106, 112-113.

Q61. Please describe the claims raised with respect to the Stone & Webster calculation?

A61. (WT) The claims raised with respect to the Stone & Webster calculation concern Stone & Webster's assumption that the pad and the surrounding soil cement are rigid and the effect that this assumption has on the earthquake accelerations used

by Stone & Webster in its stability calculation. See Ostadan Dep. at 109-111, 116-120. According to the State, the assumption of pad rigidity results in Stone & Webster's use of the peak ground acceleration in its calculation of pad stability instead of the ground acceleration associated with the natural frequency of the casks-pads-soil system. This allegedly erroneous assumption leads to an underestimation of the earthquake loads used by Stone & Webster in its stability analyses. Id. at 119.

Q62. What is the essence of the State's claims with respect to the Holtec calculation?

A62. (WT) The essence of the State's claims is that Holtec should have modeled the concrete storage cask pad as being flexible in its stability calculations instead of analyzing the cask stability assuming the pads to be rigid.

Q63. What considerations generally determine whether a concrete foundation pad should be analyzed as being rigid or flexible?

A63. (WT) All structures are flexible to some degree. However, depending upon the specific purpose of an analysis, the degree of flexibility may or may not have a significant effect on the analysis' results.

Q64. The State claims that Holtec's assumption of pad rigidity in its cask stability calculations is contradicted by ICEC's calculation for the analysis and design of the storage pads in which ICES's analyses showed the pad to be flexible. Do you agree?

A64. (WT) No. The ICEC calculation was performed for the design of the reinforced concrete pad. Thus, in order to determine the internal stresses in the pad when subjected to applied cask loads, the pad flexibility was important and thus was included. The Holtec calculation was done for to a different purpose. The calculation was to evaluate the global response of the casks supported on the pad for which the effect of pad flexibility may depend on the frequency ranges of interest.

Q65. Have you evaluated the rigidity of the pad for frequency range of interest for the peak cask response for purposes of calculating foundation damping and related parameters.

A65. (WT) Yes. I have received a Stone & Webster evaluation of the effect of pad flexibility on foundation stiffness and damping based on published results of Iguchi and Luco (1981). Using the relevant parameter values for the pad and the foundation soil, this evaluation demonstrated that the effect of flexibility on the foundation stiffness and damping properties of the pad is insignificant in the frequency range of importance to the cask response. A copy of the calculation is included as PFS Exhibit MM. I have independently reviewed this calculation and agree with the conclusions it reached.

Q66. Please describe this evaluation and its basis.

A66. (WT) Using bending rigidity of the pad as designed and shear moduli of the soils supporting the pad, Stone & Webster evaluated the dimensionless rigidity ratio of the pad relative to soil as defined in the 1981 paper of Iguchi and Luco. Based on this dimensionless rigidity ratio and the dimensionless frequencies corresponding to the frequency range of cask response between 1 and 5 Hz, the effect of pad flexibility on the pad's vertical and rocking foundation impedance functions was determined from the published results in Iguchi and Luco's paper. These impedances for the flexible pad foundation were then compared with the corresponding impedances for the rigid pad foundation case to assess the amount of differences between them. The result of this comparison shows that the effect of pad flexibility causes very small deviations in the foundation impedances from the rigid pad foundation impedances within the frequency range of interest.

Q67. Is this paper by Iguchi and Luco a recognized work in this area?

A67. (WT) Yes it is. The paper was published in a peer-reviewed journal and the results published in this paper have also been used for validating numerical analysis results using a computer program such as SASSI.

Q68. How does this evaluation relate, if at all, to ICEC's treatment of the pads as flexible in its calculation for the analysis and design of the pads?

A68. (WT) ICEC's calculation was for the purpose of determining internal stresses in the pad induced by imposed dynamic loadings of the casks. For this purpose, the

pad flexibility was included. For the purpose of determining the dynamic response motions of the casks, the insignificant effect of pad flexibility on the foundation stiffness and damping properties implies that a rigid pad assumption is reasonable for the purpose of determining the global dynamic response motions of the casks.

Q69. Referring to ICEC's calculation, Table 5.2.5-1 at ~~page 214~~ of the calculation, the State's expert, Dr. Ostadan, has claimed that your calculation "showed that the displacements [of the pad] varied by more than a factor of two and a half from one corner of the pad to the other" which clearly shows that the pad is not rigid.[1] Do you agree with this interpretation by Dr. Ostadan of your calculation?

A69. (WT) No, I do not agree with Dr. Ostadan's interpretation of the seismic loading condition. The ICEC calculation for which results were shown in Table 5.2.5-1 was performed by ICEC only for calibration purposes, to compare the results obtained using the CECSAP code to those that obtained using the SASSI code under a concentrated vertical load. The calculation was not intended to be representative of actual earthquake loadings on a pad. Thus, the displacements shown in Table 5.2.5-1 of the ICEC calculation are due to a vertical load applied to a single node of the finite element model of the pad. This node is near the corner of the pad. Under such a concentrated vertical load, vertical displacements will vary from node to node. That is to be expected. Under a more uniform loading, such as would take place under earthquake conditions, the variation off the vertical displacements of the pad would be less significant. The ICEC calculation includes one case of more uniform, 8 cask symmetric loading. The results for that case are presented in Table S-2 (page 229). For that case, the vertical displacements at all nodes are quite uniform.

Q70. Dr. Ostadan also refers to Table D-1(d) at page 234 of your calculation to support his contention that Holtec should have treated the pad as flexible. What does this table show?

[1] Declaration of Farhang Ostadan, January 30, 2001, paragraph 25.

A70. (WT) This Table shows the maximum displacements of the pad in the vertical direction as computed by ICEC at various nodes on the pad assuming two, four, and eight casks respectively are placed on the pad for the lower range, best estimate and upper range soil properties. It must be emphasized that these are maximum displacements observed at any point in time during the analysis and do not occur at a simultaneous response displacement in time. Further, the displacements in the Table are very small, being expressed in 1×10^{-3} ft. Thus, the largest displacements are on the order of 3/8 of an inch. These displacements, however, include displacements of the pad acting as a rigid body as well as any local deformations of the pad.

Q71. What do you mean when you say that the displacements set forth in your Table D-1(d) at page 234 include the displacement of the pad acting as a rigid body?

A71. (WT) When a rigid pad supported on soil is subjected to a vertical load, the pad will undergo vertical displacements without local deformations. This vertical displacement is included in the displacements on Table D-1(d) at page 234 cited by Dr. Ostadan.

Q72. Has ICEC determined the maximum local deformation or displacement of the pad for the cases set forth in Table D-1(d) at page 234?

A72. (WT) Yes. The maximum deviation of local displacement from the rigid body for the nine cases shown on Table D-1(d) is of the order of 0.01 ft, or approximately 1/8 of an inch.

Q73. Of what significance is this maximum local displacement?

A73. (WT) As stated, it depends on the purpose of the calculation. Insofar as determining internal stresses of the pad for the design of the pad, the local displacement should be included in order to capture the local maximum stresses in the pad. Insofar as determining the gross soil spring and soil damping properties for purpose of analyzing global response of the cask/pad/soil coupled system, this small local displacement would produce only secondary effects on the global dynamic response of the system.

Q74. On page 114 to 115 of his deposition, Dr. Ostadan claims that the force that ICEC calculated of the casks and the pad transferred to the soil shows an effective acceleration of less than 0.60 g, which he claims is too low given a peak ground acceleration of 0.71g. From this Dr. Ostadan concludes that the loads provided to ICEC by Holtec were not "adequate." Do you agree with Dr. Ostadan's claims?

A74. (WT) No. Since the casks on the pad are allowed to slide and/or tip with partial base up-lifting under earthquake loading, sliding and rocking of casks produce lower effective horizontal inertial load as compared to the case of casks being rigidly attached to the pad.

Q75. What are your conclusions with respect to the claims raised by the State in Section D.1.b of the Unified Contention with respect to pad rigidity?

A75. (WT) Based on the previously discussed evaluation performed by Bruce Ebbeson, the effect of pad flexibility on the pad's foundation soil stiffness and damping is small.

3. Claims Raised in Section D.1.c of Unified Contention – Evaluation of Potential Storage Pad Motion in Relation to Sliding of the Casks on the Pads

Q76. Please describe the claim raised by the State in Section D.1.c of the Unified Contention.

A76. (WT) The State claims in D.1.c of the Unified Contention that the Applicant has failed to provide a realistic evaluation of the foundation pad motion with cement-treated soil under and around the pads in relation to motion of the casks sliding on the pads in that Applicant's evaluation ignores (i) the effect of soil-cement around the pads and the unsymmetrical loading that the soil-cement would impart on the pads once the pads undergo sliding motion, (ii) the flexibility of the pads under DBE loading, and (iii) the variation of the coefficient of sliding friction between the bottom of the casks and the top of the pads due local deformation of the pad at the contact points with the cask.

Q77. On which portions of this claim are you testifying?

A77. (WT) I will be testifying with respect to (i) the effect of soil-cement around the pads once the pads undergo sliding motion and (ii) the flexibility of the pads under DBE loading.

Q78. What do you understand to be the nature of the State's claims regarding the effect of the soil cement around the pads once the pads undergo sliding motion?

A78. (WT) I understand that the State takes issue with a calculation performed by Holtec to show the effect on cask stability of having the storage pads undergo sliding. The calculation is described in an August 6, 2001 Holtec letter which PFS forwarded to the NRC on August 7, 2001.

The State claims that Holtec's calculation is overly simplistic and incorrect because it has "ignored the effect of soil-cement around the pad and the unsymmetric loading that the soil-cement will impart on the pad once the pad undergoes sliding movement." According to the State, "[t]he cement-treated soil will create an active and a passive side" and the "cracking and potential crushing of the soil-cement on the passive side and separation of the soil-cement on the active side due to lack of tensile capacity of soil-cement will impart unbalanced forces on the pad and severely impact the stability of the casks on the pads." State of Utah's Response to Applicant's Eighth Set of Discovery Requests, Response to Interrogatory No. 6.

Q79. What is your view of the State's assertion?

A79. (WT) Under PFS's 2000 year design basis earthquake, the pads have a minimum safety factor of 1.27 against sliding and thus would not be expected to slide on top of the soil underneath the pads. The sliding parametric study undertaken by Holtec was not a design basis calculation, but was intended to show the general effect that sliding of the pads would have on cask movement in the event such sliding were to occur.

The calculation demonstrates that a reduction in movement of the casks can be expected to occur should the pads undergo sliding. Sliding of the pads would reduce the loads on the casks and would be beneficial, not detrimental, to the stability of the casks. The soil cement around the pads will contribute to resisting sliding of the pad on the soil and will limit the amount of sliding if sliding were to occur.

Q80. On what do you base your opinion that the loads imparted by the soil cement would have only a secondary order effect on the stability of the casks and would not affect the validity of Holtec's calculation?

A80. (WT) The pad is surrounded by and embedded into the side soil only up to thickness of the pad which is 3 ft. Such a shallow side soil embedment contributes very little to the pad's foundation soil impedances. Thus, during a seismic event, the majority of the soil resistance to pad's motion is from the resistance of soil underneath the pad and only a relatively very small amount of resistance will be contributed by the side soil. Furthermore, since the pad stability analyses under the design basis earthquake have demonstrated that the friction or shear resistance of the soil beneath the pad alone is sufficient to resist the seismic shear load imposed on the pad, the movement of the pad relative to soil will be limited to elastic deformation of soil which is small.

Q81. What do you understand to be the nature of the State's claim in Section D.1.c(ii) that the Applicant ignores the "the flexibility of the pads under DBE loading" in evaluating the motion of the casks once the pads undergo sliding?

A81. From the deposition testimony of the State's expert witness, Dr. Ostadan,[2] I understand that this is the same claim as raised by the State in Section D.1.b of the Unified Contention which I have already addressed above.

4. Claims Raised in Section D.1.d of the Unified Contention – Lateral Variations in the Phase of the Ground Motions

Q82. Please describe the claim raised by the State in D.1.d of the Unified Contention.

A82. (RY, WT) In Section D.1.d of the Unified Contention, the State claims that the "Applicant has failed to consider lateral variations in the phase of ground motions and their effect on the stability of the pads and casks."

Q83. What is your understanding of this claim?

[2] Ostadan Dep. at 163-64, 172.

A83. (RY, WT) We understand from Dr. Ostadan's deposition that this claim is subsumed within the State's claims raised in Section D.1.a of the Unified Contention,[3] which we have discussed at length above.

5. Claims Raised in Section D.1.e of the Unified Contention – Frequency Dependency of Soil Spring and Damping Values

Q84. Please describe the claims raised by the State in D.1.e of the Unified Contention.

A84. (WT) In Section D.1.e of the Unified Contention, the State claims that "Applicant's calculation for cask sliding do not address the frequency dependency of the spring and damping values used to model the foundation soils."

Q85. What is the nature of the issue raised by the State in this claim?

A85. (WT) According to the State, Holtec inappropriately used constant numbers for the spring and damping values of the foundation soils that did not take into account the frequency dependency of these parameters. The State claims that Holtec similarly should have picked a value for soil spring and damper that corresponds to the natural frequency of the soil foundation system.

Q86. Do you agree with the State's claims?

A86. (WT) No. Based on my understanding of how the soil spring, mass, and damping coefficient values were developed and incorporated into Holtec's calculation, as described below, I do not agree that the frequency dependency effect was improperly ignored..

Q87. Why not?

A87. (RY, WT) The foundation soil springs, masses, and dampers used by Holtec were developed by Geomatrix in such a manner that they took into account the frequency-dependency of the soil foundation system.

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[3] Ostadan Dep. at 178-79.

Q88. How did Geomatrix develop the springs, mass, and damping values for the foundation soils so as to take into account the frequency-dependency of the foundation soil system?

A88. (RY, WT) The impedance functions developed by Geomatrix in Calculation No. 05996.02-G(PO18)-2) (2001), "Soil and Foundation Parameters for Dynamic Soil-Structure Interaction Analyses, 2000-year Return Period Design Ground Motions," and used by Holtec in nonlinear analyses of the cask/pad/soil interaction include soil springs, dashpots, and virtual (effective) soil masses. Different sets of these parameters for each mode of vibration (i.e., horizontal, vertical, and rocking) were developed based on formulations by Newmark and Rosenblueth in *Fundamentals of Earthquake Engineering*, Prentice Hall, Inc. (1971). Newmark and Roseblueth's treatise shows that use of spring and dashpot constants together with virtual (effective) soil masses for each mode of vibration results in excellent prediction of response of circular plates on soil throughout most of the range of excitation frequencies when compared with available "exact" solutions. Therefore, the foundation parameters (spring and dashpot constants plus virtual soil masses) used by Holtec account for the frequency dependence of the foundation impedance functions. Use of virtual soil mass as one of the foundation parameters in addition to the spring and dashpot constants is equivalent to use of frequency-dependent impedance functions in the frequency domain solution, as described below.

The frequency-dependent impedance functions of a foundation are generally defined as follows:

$$K_{ij}(\omega) = k_{ij}(\omega) + i\omega c_{ij}(\omega) \quad (i, j = 1,6) \qquad (1)$$

where k_{ij} is the real part of the impedance, ωc_{ij} is the imaginary part, and ω is circular frequency. When the virtual soil mass is used in the impedance functions together with the static soil spring stiffness, the real parts of the impedance functions, k_{ij}, become frequency-dependent as:

$$k_{ij}(\omega) = (k_0)_{ij} - \omega^2 m_{ij} \qquad (2)$$

where $(k_0)_{ij}$ is the static stiffness and m_{ij} is the virtual soil mass (as defined above).

Thus, the real parts of the impedance functions expressed equation (1) are frequency-dependent when the virtual soil mass is used along with soil spring stiffnesses.

Q89. What is your conclusion regarding the State's claims in Section D.1(e) of the Unified Contention?

A89. (WT) Since soil masses were used along with soil springs and dash-pots, the resulting foundation impedance functions used by Holtec as represented by the constant soil springs, masses, and dash-pots are a good approximation of the soil foundation impedances for the fundamental frequency of the soil foundation system for each of the six rigid-pad motion degrees of freedom.

6. Claims Raised in Section D.1.h of the Unified Contention – Use of One Set of Time Histories

Q90. Please describe the claims raised by the State in D.1.h of the Unified Contention that you will be addressing.

A90. (RY) I will be addressing the claim in Section D.1.h (ii) of the Unified Contention in which the State claims that the use of one set of time histories in Holtec's (nonlinear) cask stability analysis is inadequate because (ii) fault fling (i.e., large velocity pulses in the time history) and its variation and effects are not adequately bounded by one set of time histories. I will address how we incorporated the effects of fault fling in the development of the set of time histories used for the PFSF.

Q91. Are you familiar with the term "fault fling?"

A91. (RY) Yes.

Q92. Please describe what this term means.

A92. (RY) Fault fling is a term generically used to describe enhanced ground motions that have been observed in a number of earthquake recordings obtained very near to the causative fault rupture. A specific model that has been developed to quantify these near-fault effects is a model for what is called forward directivity. As an earthquake ruptures towards a site, the rupture moves at a speed that is near to that of the seismic waves radiating from the fault plane. Consequently, the seismic waves build up into a coherent, strong velocity pulse that arrives in the early portion of the strong shaking. In addition, there are recognizable trends in the amplitudes of ground motions that depend on the orientation of the recording location relative to the fault. Specifically, low frequency motions in the direction perpendicular to the fault (fault-normal) are, on average, greater than those in the direction parallel to the fault rupture (fault-parallel).

Q93. Did you account for these near-fault effects in the set of time histories that you developed for the PFSF?

A93. (RY) Yes.

Q94. How did you go about including these effects in the time histories for the PFSF?

A94. (RY) The first step was to account for forward directivity in the design response spectra. The model developed by Somerville and others (1997) was used to enhance all three components of the design response spectra for forward directivity effects. The east-west horizontal spectrum was then increased for fault-normal effects and the north-south component was reduced for fault parallel effects. The second step was to select a starting time history that exhibited a velocity pulse in the early portion of strong shaking. The Sturno recording of the Irpinia earthquake has large amplitude – low frequency (~0.5 Hz) motions that begin approximately 4 seconds after the start of the record. The recordings were then scaled upward until their response spectra enveloped the design response spectra.

Q95. Were conservatisms with respect to near-fault effects incorporated in the set of time histories that you developed for the PFSF design?

A95. (RY) Yes.

Q96. What are these conservatisms?

A96. (RY) The design response spectra are based on a probabilistic analysis which allows for a range of possible earthquake locations and rupture geometries. However, the near-fault effects (forward directivity and fault-normal effects) were applied using a deterministic worst-case rupture geometry that maximized their effects. The time histories were then scaled so that they envelop the design response spectra over a very broad frequency range. As a result, the response spectra for the time histories are on average five percent larger than the design response spectra.

Q97. How did you go about using a deterministic approach in determining near fault effects and why was it conservative?

A97. (RY) The near-fault effects are a function of the location of rupture initiation. I assumed the worst possible location for rupture initiation instead of randomizing the location over a distribution of possible initiation points.

Q98. How do the conservatisms embodied in the time histories developed for the PFSF compare to the conservatisms in time histories that you have either developed or are aware of for use in the design of nuclear power plant structures?

A98. (RY) In terms of enveloping the design response spectra by spectrum-compatible time histories, I would expect that the conservatism in the PFSF time histories is at least comparable to that in time histories developed for other nuclear power plants. I am unaware of any time histories for nuclear power plant design that include near-fault effects as ours do. (I understand that near-fault effects are being incorporated into the design ground motions for interim storage facilities at Diablo Canyon. However, I do not know if the near fault effects are being estimated probabilistically, or in a worst-case deterministic manner, as we have done.)

Q99. Does this conclude your testimony?

A99. (RY, WT) Yes, it does.

ROBERT R. YOUNGS
PRINCIPAL ENGINEER

EDUCATION

University of California: Ph.D., Geotechnical Engineering, 1982

University of California: M.S., Geotechnical Engineering, 1973

California State Polytechnical University, Pomona: B.S., Civil Engineering, 1969

REGISTRATION

Geotechnical Engineer, California No. 924, 1987
Civil Engineer, California No. 22519, 1973

AFFILIATIONS

American Society of Civil Engineers
American Geophysical Union
Earthquake Engineering Research Institute
Seismological Society of America
Society for Risk Assessment

SKILLS AND EXPERIENCE

Dr. Youngs has 24 years of consulting experience, with primary emphasis in hazard analysis. He has pioneered approaches for incorporating earth sciences data, and their associated uncertainties, into probabilistic hazard analyses; The work has focused on developing quantitative evaluations of hazard by combining statistical data and expert judgment. Within Geomatrix's Decision Analysis (DA) operating unit, Dr. Youngs has helped develop capabilities that integrate the fields of earth sciences, hazard analysis, and risk assessment. Representative project experience includes:

Regional Seismic Hazard Mapping/Microzonation Studies: Ech Cheliff Region, Algeria; San Juan Province, Argentina, PG&E; Mendoza Province, Argentina; Seismic Design Mapping Project, State of Oregon, Oregon Department of Transportation

Seismic Source/Ground Motion Characterization for Hazard Analysis: Diablo Canyon Power Plant, PG&E; WNP-2 Hanford Power Plant, WPPSS; Hanford Reservation, Westinghouse Hanford Co.; Palo Verde Nuclear Generating Station, Arizona Power; Yucca Mountain Nuclear Waste Repository Site, U.S. Department of Energy

Development of Hazard Methodologies/Uncertainty Treatment: Seismic Hazard in the Eastern United States, Electric Power Research Institute (EPRI); Maximum Earthquakes in Eastern United States, EPRI; Expert Elicitation Methodology Demonstration for Yucca Mountain Performance Assessment, EPRI; Characterization of seismic hazard in Southern Ontario, Atomic Energy Control Board, Canada

Hazard Analyses for Performance Assessment of Built Structures: seismic hazard at San Francisco-Bay Area bridges, California Department of Transportation (CDOT); seismic hazard at Humboldt Bay bridges, CDOT ; seismic hazard and site response studies for K-reactor, Westinghouse Savannah River Co.; seismic hazard analysis for operating nuclear power plants in Spain, Westinghouse Energy Systems Europe; seismic hazard analysis and development of earthquake ground motions for Blue River Dam, Oregon, USACOE.

Hazard Analyses for Development of Design Criteria: Seismic hazard assessment for the New Production Reactor at Savannah River Site and Idaho National Engineering Laboratory (DOE); WNP-1, 2,4 Hanford and WNP-3, 5 Satsop, WPPSS; Potential High-Level Radioactive Waste Repository Site, Yucca Mountain, DOE; Waste Tank Sites at Hanford, Washington, Westinghouse Hanford Co.

Performance Assessment of Natural Systems: Demonstration of risk-based total system performance assessment, EPRI, DOE; Earthquakes/tectonics expert elicitation project, EPRI; Probabilistic volcanic hazard analysis, Yucca Mountain, TRW and DOE; Fault displacement hazard analysis for Yucca Mountain, USGS, DOE

ROBERT R. YOUNGS
PRINCIPAL ENGINEER

PUBLICATIONS

"Strong ground motion attenuation relationships for subduction zone earthquakes." Youngs, R.R., Chiou, S.J., Silva, W., and Humphrey, J.: Seismological Research Letters, v. 68, n. 1. January/February 1997.

"Seismic hazard mapping for highway design in the state of Oregon." Youngs, R.R.: Proceedings, Design of Highway Bridges for Extreme Events, Federal Highway Administration, Atlanta, Georgia. December 1996.

"Regional probabilistic seismic hazard mapping with uncertainty: An example from the state of Oregon, USA." Youngs, R.R., Coppersmith, K.J., Hanson, K., DiSilvestro, L., and Wells, D.: Fifth International Conference on Seismic Zonation, Nice, France. October 17-18, 1995.

"Earthquake ground shaking hazard in Utah." Proceedings, Earthquake Engineering Research Institute Wasatch Front Seismic Risk Regional Seminar, v. 1, Salt Lake City, Utah. November 29-30, 1994.

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"Computer applications in geotechnical earthquake engineering." Chang, C.-Y., and others: Geotechnical News, v. 12, n. 2, p. 36-38. June 1994.

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"Assessing fault rupture hazard for the proposed repository at Yucca Mountain, Nevada: Demonstration of a methodology using expert judgments." Perman, R.C., Coppersmith, K.J., Youngs, R.R., and Shaw, R.: Proceedings, Fourth Annual International Conference on High Level Radioactive Waste Management, v. 1, p. 2086-2091. 1993.

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"Improved methods for seismic hazard analysis in the western United States." Coppersmith, K.J.: Proceedings, Fourth U.S. National Conference on Earthquake Engineering, v. 1, p. 723-731. 1990.

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"Issues regarding earthquake source characterization and seismic hazard analysis within passive margins and stable continental interiors." Coppersmith, K.J. , Youngs, R.R.: Earthquakes at North-Atlantic Passive Margins–Neotectonics and Postglacial Rebound (Gregersen, S. and Basham, P., eds.), NATO ASI Series C, v. 266, p. 601 – 631. 1989.

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"Probabilistic analysis of earthquake ground shaking hazard along the Wasatch Front, Utah." Youngs, R.R., Swan, F.H., Power, M.S., Schwartz, D., and Green, R.: United States Geological Survey–Professional Paper on Seismic Hazards in Utah (in press). Preprinted and Assessment of Regional Earthquake Hazards and Risk along the Wasatch Front, Utah United States Geological Survey Open File Report 87-585, v. 2, p. M1-110.

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"Seismic hazard methodology for the central and eastern United States, Volume 1: Methodology." with Risk Engineering, Woodward-Clyde Consultants, and Cygna Corporation. Electric Power Research Institute Publication NP-4726. 1986.

"Capturing uncertainty in probabilistic seismic hazard assessments within intraplate environments." Coppersmith, K., Youngs, R.R.: Proceedings, Third National Conference on Earthquake Engineering, Charleston, South Carolina, v. 1, p. 301-312. August 24-28, 1986.

"Seismic hazard assessment of the Hanford region, eastern Washington State." Coppersmith, K.J., and others: Proceedings, Department Of Energy Natural Phenomena Hazards Mitigation Conference, p. 169-176. October 1985.

"Implications of fault slip rates and earthquake recurrence models to probabilistic seismic hazard estimates." Youngs, R.R., Coppersmith, K.J.: Bulletin, Seismological Society of America v. 75, p. 939-964. 1985.

"Geotechnical features of Fur Seal Island design." Luscher, U., and others: Proceedings, American Society of Civil Engineers Conference on Civil Engineering in the Arctic Offshore, San Francisco. March 25-27, 1985.

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"Assessment of confidence intervals for results of seismic hazard analysis." Kulkarni, R., Youngs, R.R., and Coppersmith, K.J.: Proceedings, Eighth World Conference on Earthquake Engineering v. 1, p. 263-270. 1984.

"Incorporation of geologic information and associated uncertainty in seismic hazard analysis." Invited paper presented at Specialty Seminar on Fundamentals of Probabilistic Risk Assessment, Stanford University, Stanford, California, July 19, 1984, and published in Earthquake Engineering Research Institute Publication No. 84-06, v. 11, p. 38-58.

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"Peak horizontal and vertical accelerations, velocities and displacements on deep soil sites during moderately strong earthquakes." Sadigh, K., and Power, M.S.: Proceedings, Second International Conference on Microzonation, San Francisco, California, v. II, p. 801-811. 1978.

"Drainage effects on seismic stability of rockfill dams." Sadigh, K., and Idriss, I. M.: Proceedings, American Society of Civil Engineers Specialty Conference on Earthquake Engineering and Soil Dynamics, Pasadena, California. 1978.

EDUCATION

Ph.D. - Civil Engineering, University of California, Berkeley, 1971
M.S. - Civil Engineering, University of California, Berkeley, 1968
B.S. - Civil Engineering, National Taiwan University, 1964

EMPLOYMENT HISTORY

Professional Experience

1990-present - President, International Civil Engineering Consultants, Inc., Berkeley
1987-90 - Principal Engineer and Assistant Chief Civil/Structural Engineer, Bechtel Corporation, San Francisco
1985-87 - Principal Engineer and Head of Special Structures Group, Bechtel Corporation, San Francisco
1977-85 - Engineering Group Supervisor, Special Structures Group, Bechtel Power Corporation, San Francisco
1976-77 - Engineering Specialist, Offshore Development Engineering, Inc., Berkeley
1973-76 - Senior Engineer, Bechtel Power Corporation, San Francisco

Academic Experience

1971-73 - Post-Doctoral Research Engineer, Earthquake Engineering Research Center, University of California, Berkeley

PROFESSION REGISTRATION

Civil Engineer, State of California

PROFESSIONAL SOCIETIES

American Society of Civil Engineers, Member
Earthquake Engineering Research Institute, Member
American Society of Mechanical Engineers, Technical Committee Member

AWARDS AND HONORS

1990 Bechtel Outstanding Technical Paper Award
1989 Bechtel Outstanding Technical Paper Award
1988 Bechtel Outstanding Technical Paper Award
1970 William H. and Helena I. S. Popert Research Fellowship

PUBLICATIONS

Over 60 technical papers, over 150 technical and project reports, 14 engineering computer programs.

SUMMARY OF EXPERIENCE

Dr. Tseng has more than 29 years of professional experience. He received his Ph.D. from the University of California, Berkeley (UCB) in 1971 having specialized in structural engineering and structural mechanics. He then joined the UCB Earthquake Engineering Research Center (EERC) as a post-doctoral research engineer. During his 2-1/2 years in EERC he made major contributions to advancing the state-of-the-art of seismic design and analysis of bridge structures, including the development of computer programs BSAP for linear analysis and YIELD and NEABS for nonlinear analyses. These programs with subsequent enhancements and modifications are now being used widely by bridge designers.

In addition to his research in the early 1970's, Tseng also actively participated in the seismic design and analysis of bridges, including the long-spanned Parrott Ferry Bridge in California and the cable-stayed Penang Bridge in Malaysia. He also performed seismic analyses for several offshore platforms off the coasts of California, Alaska, and Mexico.

In 1973, Tseng joined Bechtel of San Francisco where he served 16 years before leaving his position as Principal and Assistant Chief Civil/Structural Engineer in March 1990 to join with Dr. Joseph Penzien in forming ICEC. During the last 12 years at Bechtel, he headed the Special Structures group performing research and development and providing technical consulting services to many nuclear power projects, including the Susquehanna, Limerick, Pilgrim II, Hope Creek, Skagit, Trojan, Tsuruga II, Sequoyah, Browns Ferry, Watts Bar, Bellefonte, and Diablo Canyon nuclear power plant projects. During the past 10 years, he played a lead role in evaluating the following engineered facilities:

(1) Diablo Canyon Nuclear Power Plant, developing plans and methodologies to assess soil-structure interaction, to evaluate structural response due to spatial incoherence of seismic ground motions, and to evaluate nonlinear base uplift response for the Long-Term Seismic Program, and assessing the performance of concrete masonry walls,

(2) Sequoyah, Browns Ferry, and Watts Bar Nuclear Power Plants, conducting seismic response analyses and performance evaluations of seismic Category-I structures for Tennessee Valley Authority (TVA),

(3) Diablo Canyon and Watts Bar Nuclear Power Plants, developing methodologies and computer programs for evaluating seismic response of equipment and systems supported on floors and platforms, including equipment-structure interaction effects,

(4) Nuclear Power Plant Containment Building Model (1/4-scale), Lotung, Taiwan, conducting soil-structure interaction analyses and correlating results with field-test data under the joint TPC/EPRI program and developing soil-structure interaction analysis guidelines for industry applications under EPRI sponsorship,

(5) Advanced Boiling-Water Reactor, performing seismic response analyses and providing SASSI technology transfer to General Electric Nuclear Energy System,

(6) Field-Test Structural Model, Hualien, Taiwan, developing conceptual designs and evaluating their expected seismic performance under EPRI sponsorship,

(7) Bellefonte Nuclear Power Plant, conducting seismic analyses of all seismic Category-I structures using the current state-of-the-art seismic modelling and analysis techniques to regenerate seismic loads and floor response spectra for seismic performance evaluations for TVA,

(8) Underground gas transmission pipelines, performing engineering evaluations of the structural fitness-for-service conditions of pipelines 57A and 57B under severe ground settlements at levee crossings for Pacific Gas & Electric Company (PG&E),

(9) Benicia-Martinez Bridge, performing seismic soil-structure interaction analyses for the deep caisson foundation systems of the bridge to develop the foundation impedances and scattered seismic input motions for super-structure seismic vulnerability evaluation,

(10) Mokelumne Aqueduct Seismic Upgrade Project, performing seismic response analyses for determining the seismic demands on the aqueduct system for the East Bay Municipal Utility District (EBMUD),

(11) Lafayette Reservoir intake/outlet tower, performing seismic response analyses, evaluating the structural capacity, and providing recommendations for seismic retrofit for EBMUD,

(12) Department of Energy Savannah River Facilities, as a member of the Peer Review Panel for soil-structure interaction performing a technical review of seismic SSI analyses conducted for the high-level waste underground storage tanks,

(13) Richmond-San Rafael Bridge, generating multiple-support seismic motion inputs and performing seismic soil-structure interaction analyses to develop the foundation impedances and scattered foundation input motions for super-structural seismic vulnerability evaluation,

(14) San Mateo-Hayward Bridge, conducting free-field site response analyses to determine the strain-compatible soil properties and associated free-field site soil response motions, developing the pile-group foundation stiffness matrices at the pilecaps for as-built and retrofitted piers, evaluating the effect of soil-pile kinematic interaction (foundation scattering) on seismic response motions at the pilecaps for two-bell piers,

(15) Bronx-Whitestone Bridge, New York, developing four sets of three-component rock motion time histories compatible with target response spectra and target coherency functions, developing foundation impedances and seismic scattered foundation input motions at four supports of the main-suspended spans of the bridge for use in seismic response analyses of bridge structural system,

(16) San Francisco-Oakland Bay Bridge, East Span Replacement Seismic Safety Project, performing independent check of the main-span cable-stayed and suspension bridge design options including assessing soil-structure interaction effects of the main-span tower foundation systems,

(17) Taiwan Power Company, Nuclear Power Plant No. 4, Lungmen Nuclear Advanced BWR Units 1 & 2 in Northern Taiwan, performing seismic analyses and developing seismic design forces and displacements to the detailed designer for all seismic Category-I nuclear-island structures and major systems, including the Reactor Buildings, Control Buildings, and Auxiliary Fuel Buildings, and

(18) Taiwan High Speed Rail Project, performing a two-phase study, in cooperation with CTCI Corporation in Taiwan, on assessing the HSR-train-operation-induced ground vibration characteristics and amplitudes in Tainan Science-Based Industrial Park, where vibration-sensitive high-tech manufacturing facilities are located, and on developing ground-vibration mitigation measures for implementation to the Taiwan HSR civil/structural works.

Currently, as a principal in ICEC, Tseng is actively engaged in projects similar to those described above and is expanding his activities to other specialty areas as well. He currently serves as a consultant to (1) Bechtel Infrastructure Corporation, (2) Pacific Gas and Electric Company on the Diablo Canyon Power Plant seismic related work, (3) Tennessee Valley Authority (TVA) on Watts Bar and Bellefonte Nuclear Plants seismic related issues, (4) Electric Power Research Institute (EPRI) on Hualien, Taiwan soil-structure interaction experimental program and on seismic instrumentation for nuclear power plants, and (5) GE Nuclear Energy on Taiwan Power Company, Nuclear Power Plant No. 4, Lungmen Nuclear Units 1 & 2 seismic design and analysis related work.

Recent Technical Papers

W. S. Tseng

1. "Soil-Structure Interaction Analysis Guidelines Based on Lotung Experiment in Response to the Revised Standard Review Plan," (with A. H. Hadjian, Y. K. Tang, and H. T. Tang), Paper No. IX/3, *Proc.*, Third Symposium on "Current Issue Related to Nuclear Power Plant Structures, Equipment, and Piping," Orlando, Florida, December 5-7, 1990.

2. "The Learning from the Large-Scale Lotung Soil-Structure Interaction Experiment," (with A. H. Hadjian, et al.), *Proc.*, Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, Vol. III, St. Louis, Missouri, March 11-15, 1991.

3. "Seismic Performance Investigation of the Hayward-BART Elevated Section Instrumented Under CSMIP," Paper No. 9, SMIP91 Seminar on Seismological and Engineering Implications of Recent Strong-Motion Data, Sacramento, California, May 30, 1991.

4. "Parametric Evaluation of Intermediate SSI Solutions on Final Response," (with F. Ostadan, et al.), Paper No. K04/1, *Proc.*, 11th Structural Mechanics in Reactor Technology (SMiRT-11), Tokyo, Japan, August 18-23, 1991.

5. "Assessment of Soil-Structure Interaction Practice Based on Synthesized Results from Lotung Experiment--Earthquake Response," (with A. H. Hadjian, et al.), Paper No. K08/7, *Proc.*, 11th Structural Mechanics in Reactor Technology (SMiRT-11), Tokyo, Japan, August 18-23, 1991.

6. "Post-Prediction Analysis and Parametric Studies for the Lotung Soil-Structure Interaction Experiment," (with Kiat Lilhanand, Y. K. Tang, and H. T. Tang), Paper No. K04/3, *Proc.*, 11th Structural Mechanics in Reactor Technology (SMiRT-11), Tokyo, Japan, August 18-23, 1991.

7. "Development of Power Spectral Density Functions Consistent with Design Response Spectra," (with Kiat Lilhanand), Paper No. K01/5, *Proc.*, 11th Structural Mechanics in Reactor Technology (SMiRT-11), Tokyo, Japan, August 18-23, 1991.

8. "Soil-Structure Interaction Analysis Incorporating Three-Dimensional Spatial Incoherency of Ground Motions," (with K. Lilhanand and D. Hamasaki), *Proc.*, 12th International Conference on Structural Mechanics in Reactor Technology (SMiRT-12), Stuttgart, Germany, August 1993.

9. "Seismic Response Analysis of Nuclear Power Plant Structures Considering Spatial Incoherency of Ground Motions," (with K. Lilhanand, D. Hamasaki, H. T. Tang, and Y. B. Tsai), *Proc.*, 4th International Topical Meeting on Nuclear Thermal Hydraulics, Operations and Safety, Taipei, Taiwan.

10. "Development of Multiple-Support Ground Motions for Seismic Vulnerability Evaluations of Major Bridges in Northern California," (with K. Lilhanand, N. A. Abrahamson, and C.-Y. Chang) Proc., 5th U.S. National Conference on Earthquake Engineering, Chicago, July 10-14, 1994.

11. "Seismic Evaluation of Benicia-Martinez Bridge," (with W. D. Liu, K. Lilhanand, C.-Y. Chang, R. A. Imbsen, and F. Li), Proc., 5th U.S. National Conference on Earthquake Engineering, Chicago, July 10-14, 1994.

12. "Cable-Stayed Bridge for High Speed Rail in Taiwan," (with Jeder Hsieh and Jiri Strasky), *Proc.*, International Association of Bridge Structural Engineering (IBASE) Conference, Deauville, France, October 12-15, 1994.

13. "Vibrations of Elevated Structures and Bridges Caused by High Speed Train Loadings," (with J. Penzien and Kee-Dong Kang), *Proc.*, Korean Society of Civil Engineers (KSCE) Annual Meeting, Pusan, Korea, October 21-22, 1994.

14. "Development of Structural Fitness-For-Service Criteria for Evaluation of an Underground Natural Gas Pipeline," by Wen S. Tseng and Chih-Hung Lee, July 1994.

15. "Soil-Structure Interaction Effects for Deep Foundation Systems of Long-Span Bridges," by Wen S. Tseng, C. Y. Chang, W. D. Liu, and Rouppen Donikian, April 1995.

16. "Seismic Performance Evaluation of Major Steel Bridges in California" (with R. R. Donikian and C. Y. Chang). *Proc.*, American Society of Civil Engineers (ASCE) Structures Congress XIII, Boston, Massachusetts, April 2-5, 1995.

17. "Seismic Response Analysis of Nuclear Power Plant Structures Considering Spatial Incoherency of Ground Motions," (with K. Lilhanand, D. Hamasaki, H. T. Tang, and Y. B. Tsai), Nuclear Science Journal, Vol. 32, No. 2, April 1995.

18. "Structural Performance Criteria for Fitness-for-Service Evaluations of Underground Natural Gas Pipelines," (with Chih-Hong Lee), *Proc.*, 2nd International Conference on Advances in Underground Pipeline Engineering, Seattle, Washington, June 25-27, 1995.

19. "Soil-Foundation-Structure Interaction Analysis by the Elasto-Dynamic Method," *Proc.*, the Fourth Caltrans Seismic Research workshop, Sacramento, July 9-11, 1997.

20. "Hybrid Method for Evaluating Soil-Foundation-Structure Interaction Effects," W.S. Tseng and J. Penzien, *Proc.*, 5th Caltrans Seismic Research Workshop, sacramento, CA, June 16-18, 1998.

21. "Soil-Foundation-Structure Interaction," W.S. Tseng and J. Penzien, Chapter 42 of Handbook of Bridge Engineering, Chen, W.F. and Duan, L., Editors, CRC Press, LLC, 2000.

JUDGE FARRAR: Go ahead, Mr. Gaukler.

MR. GAUKLER: I would like to introduce -- I would like to introduce into the record at this time, two prefiled exhibits. The first one is PFS Exhibit LL, identified as Geomatrix Evaluation of Spatial and Temporal Variation of Ground Bulletin for the Private Fuel Storage facility, Geomatrix evaluation. And PFS Exhibit MM, Sweat Calculation SC-21, Evaluation of Cask Storage Pad Flexibility. And with respect to Exhibit MM in the portion that we've -- the book that we gave Your Honors and the parties, we had some extra pages, the last page of the exhibit should be A-2 of attachment A, and we added five or six additional pages in the copy that we had sent out previously that we removed from the books that we handed out this morning. They were extraneous materials all related to the exhibit.

And also, we've handed out and would like to have marked as PFS Exhibit 85, excerpts from the ICEC calculation, and we'll be handing out shortly, as soon as they come from downstairs, the figure referenced from the SAR, Safety Analysis Report recovered by Dr. Wen Tseng, Figure 1.2-1, which will be PFS Exhibit 84. Excuse me, we'll

make the SAR should be 84 and the ICEC calculation should be 85.

JUDGE FARRAR: Are those new exhibits the parties have not -- the other parties have not seen?

MR. GAUKLER: I've talked with counsel for the State. I believe they have no objection to those two new exhibits, to my understanding.

JUDGE FARRAR: Well, on the first two, LL and MM, is there any objection to their admission, Ms. Nakahara?

MS. NAKAHARA: No objection.

JUDGE FARRAR: Mr. Turk?

MR. TURK: No objection.

JUDGE FARRAR: Is it premature to do 84 and 85? Mr. Gaukler said something, you needed the witnesses to address or --

MR. GAUKLER: They may want to address and cross. It's up to the State. If they're satisfied right now.

MS. CHANCELLOR: With what, Your Honor?

JUDGE FARRAR: Exhibits 84 and 85, which are not in this book that was handed out.

MR. GAUKLER: Those are the excerpts of the ICEC calculation that we talked about.

MS. CHANCELLOR: Mr. Gaukler and I spoke about that on the weekend, and we have no objections to 84 or 85. I was just looking to see whether the SAR Figure 1-2.1 was entered in Utah O. That was that big chart that Mr. Nelson had.

MR. GAUKLER: I wasn't here.

MS. CHANCELLOR: If you want to do it again, that's fine.

MR. GAUKLER: Let's do it again.

MS. CHANCELLOR: We do, however, Your Honor, reserve the right to cross-examine Dr. Tseng on Exhibit MM. We note that it isn't authored by him.

JUDGE FARRAR: Fine. With that reservation, Mr. Turk, any objection?

MR. TURK: No, Your Honor.

JUDGE FARRAR: Then we'll have -- these four exhibits will be admitted.

(EXHIBITS-LL, MM, 84 & 85
WERE MARKED AND ADMITTED.)

JUDGE FARRAR: Mr. Gaukler, did you have anything else for the witnesses? They're ready for cross-examination?

MR. GAUKLER: That's correct.

JUDGE FARRAR: And under our procedures,

Applicant witnesses are first cross-examined by the Staff. Mr. Turk, go ahead.

MR. TURK: Your Honor, may I ask for a clarification?

JUDGE FARRAR: Certainly.

MR. TURK: I would have expected that we would follow the State in our cross. Is there a reason --

JUDGE FARRAR: Yes, at one of the pre-hearing conferences, the Staff suggested that since it starts out in life, when an application is first filed as neutral, that it would like to go last to have the last word. We, instead, accepted the State's view that since at this point, you're a proponent of the application -- a proponent of the position that a license should be granted, that it's better to have the Applicant and the Staff, in effect, have their position on the record so that when the State starts its cross-examination, they have the whole opposition case in front of them. We did at that time, however, reserve the Staff's right if something startling is disclosed during the course of the witness's testimony, something that might cause the Staff to reevaluate the position it's taking on the merits, that we would

give them a chance to explore that and, in effect, have the last word on that. But basically, whenever either an Applicant or Staff witness is on, the other one will go first followed by the State. And I think that's what we did on hydrology and aircraft.

MR. TURK: I appreciate Your Honor's ruling. I would just note for the record, though, that we think there would be an advantage to have the Staff follow the State. I'm willing to proceed at this time with this panel, but there may be instances in which the State develops information through its cross-examination that we wish to follow up on.

JUDGE FARRAR: If that happens, we'll let you do that. We -- I guess there's a simple rule we're following here. The Applicant has the burden of proof on the case as a whole, and so they go first and last. The State has some kind of burden on their contention, and it's fair from their point of view to have the whole case -- the whole proponent case in front of them as they try to challenge it.

MR. TURK: Thank you, Your Honor.

MR. GAUKLER: Would it be appropriate to

take a five-minute break now since we're just starting cross?

JUDGE FARRAR: Yeah, why don't we do that. And we were very good the first few days of week one of coming back when I told you to. People were very bad in the third week about coming back. Let's be fair to -- you know, let's pick a time and everyone be back, so we're not waiting for one person. My watch, which we will go by, now says 10:15. Let's be back at -- does anyone need a long break to get ready for the -- good, let's be back in five minutes, 10:20.

(A recess was taken.)

JUDGE FARRAR: I think everyone is back, but given the logistics of the hotel, maybe five minutes is too short for everybody. So maybe we'll make that 10 next time. Ms. Chancellor, when you're ready, go ahead.

MS. NAKAHARA: No, Mr. Turk.

JUDGE FARRAR: Oh, right.

MR. GAUKLER: Let me just say for the record, I handed out during the break, Exhibit 84. So it's a one-page layout with 1.2-1. It's PFS Exhibit 84.

MR. TURK: I'm ready, Your Honor.

JUDGE FARRAR: I apologize for the 10 seconds we lost by me not looking at my chart before I called on the proper lawyer. Mr. Turk, go ahead.

MR. TURK: Your Honor. I'm starting with No. 3, I'm skipping those first two items under my plan.

CROSS EXAMINATION

BY MR. TURK:

Q. Dr. Tseng?

DR. TSENG: Yes.

Q. How do you pronoun your name?

DR. TSENG: Tseng.

Q. Tseng?

DR. TSENG: Yes.

Q. Let me introduce myself to both of you. My name is Sherwin Turk. I'm an attorney for the NRC Staff.

Dr. Tseng, I'd like to ask you first about the term that's used in Answer 30 of your testimony.

DR. TSENG: Yes.

Q. The last sentence uses the phrase seismic soil-structure interaction analyses. Could

you explain what is a soil-structure interaction analyses?

DR. TSENG: Okay, I will. It is during dynamic response. The structure and soil, they actually move together to some degree, and the interaction is administered with the soil and structure analyzed together to address the interaction between the structure and the supporting soil. And this type of analysis, we generally refer to as seismic soil dash structure interaction.

Q. Is it correct to say that in some instances, the structure has an effect on the soil's behavior and the soil has an effect on the structure's behavior?

DR. TSENG: That's correct.

MS. NAKAHARA: Your Honor, could I ask Dr. Tseng to move the mike a little closer.

JUDGE FARRAR: Yes, and I'd ask all the witnesses. Even though a particular lawyer is asking for the answer, you're really talking for the benefit of the court reporter and the record, so make sure that everyone can hear you. Thank you.

Q. (By Mr. Turk) Is it important in your

opinion that soil-structure interactions be considered when you're studying the potential seismic response of a structure?

DR. TSENG: In general, yes, but it depends on particular problems. In a particular case, the effect may be small and become manageable. On the other hand, there are cases where they will be quite important. But in general, we all have to make assessment to see whether it's important or not. If it's not important, then we may just choose not to do the analysis per se.

Q. In your Answer 30, you mention NUREG-0800, which, if I'm not mistaken, is Standard Review Plan used by the Staff for evaluating nuclear power plants' applications?

DR. TSENG: That's correct.

Q. Do you recall how NUREG-0800 deals with the question of conducting soil-structure interaction analyses?

DR. TSENG: Yes. In general, this is speaking of partly my memory now. I don't have that document with me. It requires a site response analysis. It requires addressing uncertainties of soil properties, and it requires to run a time

history response analysis, addressing significant frequency range that the structure response will be, and et cetera. Now, there may be other detail requirements spelled out for all the different steps. It also recommends or put guidelines what type of method that can be used or should be used, that will be acceptable to the NRC Staff.

MR. TURK: Your Honor, just let me see if I can find the right location in NUREG-0800.

Q. (By Mr. Turk) Dr. Tseng, I'm looking at Section 3.7.2.

DR. TSENG: Yes.

Q. Is that the section which soils structure discuss?

DR. TSENG: That's correct.

Q. And in particular, Section 3.7.2 is entitled Seismic System Analysis, and under areas of review, item four is entitled Soil-structure Interaction?

DR. TSENG: Yes.

Q. That's correct, that's your recollection?

DR. TSENG: That's correct.

Q. I'd like to turn to answer 55 in your testimony. I believe this answer was given both by

Dr. Youngs and Dr. Tseng. This is on page 19 of your testimony. The second sentence of your Answer 55 states, "The calculations presented by Holtec show that there are very large margins in the range of cask movements calculated for the design earthquakes."

Can you be more specific about that statement? Do you recall what margins were shown?

DR. YOUNGS: I don't recall the numbers in detail. I believe that under the design earthquakes movement on the order of a few inches were calculated, which were much less than separation distances between casks.

Q. Dr. Tseng, do you have anything to add to that answer?

DR. TSENG: Yeah, I believe that the margin referring to the calculated motion of the casks enter design level earthquake, which is a few inches, if I recall, about four inches, up to four inches, whereas the separation between casks still have a margin -- a much larger margin in it. So that's the statement referring to.

Q. It was about four inches?

DR. TSENG: (Nodding affirmatively.)

Q. There are some acronyms for computer

codes using your testimony. This appears in answer 67 and 69. One of them is the SASSI, S-A-S-S-I computer code, and another one is the CECSAP, C-E-C-S-A-P computer code. Could you describe what those codes are and also explain how they were used with respect to the PFS application?

DR. TSENG: Okay, I will. The two computer program referring to the first one is CECSAP. CEC being abbreviation of all accompanying international civil engineering consultants, CEC, and SAP being abbreviation for structure analysis program. And CECSAP is just a general purpose structure analysis program that we have utilized for the PFS case in doing the pad analysis and design.

The second computer program, SASSI, is abbreviation for system for analysis of soil-structure interaction, and that's a computer code issue or license or make available from the University of California at Berkeley, which is a general soil-structure interaction analysis program that had been used quite extensively in the industry. And in PFS project, we have also utilized this program in checking our analysis, design analysis of the pad using the CECSAP

program. And both of these program applications are documented in our calculations.

Q. Do you know whether the NRC Staff has accepted either of those computers codes for use in nuclear facility licensing?

DR. TSENG: Both programs have been verified and documented in accordance with our QA, quality assurance procedures. SASSI program, since it's a university program, it has been implemented by different companies, and many companies have applied them to different nuclear projects. And during that nuclear application, I think the Staff will review that particular application. And my personal involvement, I know that there was several nuclear projects that have been accepted as application. And then CECSAP is a general structure analysis program which is again very similar to many companies adopted in the so-called SAP program originally developed by University of California Berkeley, and each application on the project, again, the Staff would review, and based on the QA documentation procedures and so on, would accept that for each application.

JUDGE FARRAR: Mr. Turk, let me interrupt there. What was the one word answer to

your question? Was that a no or a yes?

MR. TURK: I understand the witness to have said that he has been involved in various --

JUDGE FARRAR: No, you asked if the Staff approved it.

MR. TURK: Yes, and he gave me an answer that said yes in the instances in which he's been involved.

JUDGE FARRAR: Okay. It would help if you answered yes or no at the beginning, because I thought I heard that a lot of other people had approved it, but not the Staff. So I think -- and I don't mean to embarrass you, but for all the witnesses, the question, has the Staff approved it, the answer is yes or no and then we may not need any more than that, or you can always elaborate on an answer. Someone cross-examining cannot insist that you just answer yes or no, but it often starts with yes or no and then give your explanation so we know where you're headed.

DR. TSENG: Yes, Your Honor.

JUDGE FARRAR: Thank you.

Q. (By Mr. Turk) And just so the record is clear, is it correct to say yes, that to your knowledge, the Staff has accepted it?

DR. TSENG: Through the PFS application, yes.

Q. I'd like to ask you to help me with a few terms that apply -- I'm sorry, that appear in your testimony that I think are going to come up repeatedly in the next several weeks. First, you use the term damping in your Answer 75. Dr. Tseng, can you explain what is meant by the term damping?

DR. TSENG: Damping is a measure of description of energy dissipation characteristic of a vibration system. If damping is zero, then the vibration would continue on and on without attenuated or diminished. If damping is high, then the vibration would diminish much faster, and that's a measure of damping. That's a characteristic of the word damping.

Q. So damping is, in effect, a reduction of the -- is it the --

DR. TSENG: Energy dissipation mechanism.

Q. Thank you. Also in Answer 88, which I believe both of you have answered, you use several other terms. I'm going to go through them one-by-one and just ask for you to define what you mean when you use these terms. First, the term

impedance function. Could you explain what that is?

DR. TSENG: Okay. Impedance function is a function complex variant. It means that there is a real part and an imaginary part. And it's the measure of dynamic stiffness and energy dissipation combined together. The real part of that impedance function represents a stiffness and imaginary of that represent energy dissipation characteristic. And is a measure of how the foundation may interact with a structure, the dynamic characteristic of the foundation.

Q. How does soil stiffness enter into that?

DR. TSENG: The impedance function, as I mentioned earlier, have a real part. It's a complex variant function, and it's generally a function of frequency. The real part of that reflect the stiffness of the soil.

Q. If a soil is more stiff than other soil, would that --

DR. TSENG: Then the real part of impedance function would be bigger, a bigger number.

Q. When you say it would be a bigger number, how does that affect the structural

response?

DR. TSENG: It generally means it will be stiffer support to the structure, and if the structure is -- have a constant mass, that means the frequency of the soil-structure system will be higher.

Q. Okay. Another term you use is the soil spring. Could you explain what that is?

DR. TSENG: Soil spring generally is kind of an engineering term to describe the real part of impedance function earlier, but generally, it is a simplified, constant version of that impedance function. Soil spring has a soil stiffness which generally reflect the foundation stiffness of a soil-structure system.

Q. Is it correct to say that when you describe a soil spring, you're really putting together a theoretical concept describing the soil as if it behaves in a manner of a spring?

DR. TSENG: The soil spring per se reflect the foundation stiffness, if you will, of the supporting soil media to a structure or to a foundation.

Q. And if soil is stiffer than some other soil --

DR. TSENG: If soil is stiffer, the soil spring has a stiffness value will be bigger, and if the foundation is softer, the soil is softer, then the soil spring matter will be low or small.

Q. Another term --

JUDGE FARRAR: Mr. Turk, let me ask that, because your question was much like what I was thinking. Why is the word spring in there? In other words, are you doing this mathematically as though it were like a common spring?

DR. TSENG: They use it -- that soil spring is like a mathematical like you use your spring. The variation of that value, though, thus involve the theory that counsel was just mentioning.

JUDGE FARRAR: Go ahead.

MR. TURK: Thank you.

Q. (By Mr. Turk) There's another term that I have to admit I've never heard before, and that's dashpot. What is a dashpot?

DR. TSENG: Again, the dashpot is a mechanical terminology for a damping -- a damper, which involves the damping efficiency. Just mention earlier the energy dissipation characteristic, if it is a viscous type, this is

proportional to velocity, then you would call it a damper or dashpot.

Q. Is a dashpot a localized occurrence or is this something that would occur across the entire site? In other words, is it a small, local variation in the stiffness?

DR. TSENG: No. In the case of application in soil-structure interaction, it represent the entire foundation's characteristic. Energy dissipation characteristic.

Q. And one last question, in that same answer, you use the phrase virtual, parentheses, effective, closed parentheses, soil masses. Could you explain what you mean by that term?

DR. TSENG: Okay. When the structural vibrate, there is a portion of the soil which would tend to vibrate with the structure. And in a very loose term, this virtual mass try to capture this amount of mass or inertia of the soil that would go with the structure. And a measure of that is commonly called virtual mass or effective soil mass. And it does -- and the inclusion of that also changes somewhat of the structure, the soil-structure frequency. And that's the definition of soil mass referring here in the

answer.

Q. Thank you.

MR. TURK: Your Honor, may we take a moment? May we go off the record for a moment, also?

JUDGE FARRAR: Yes.

(A discussion was held off the record.)

MR. TURK: Your Honor, that's all the examination I have for the witnesses. I think it would be useful, however, if we put into evidence the portion of NUREG-0800 to which we referred, unless the parties agree that the Board may simply take judicial notice and that way there's no reason to even introduce it.

JUDGE FARRAR: That's a Staff guidance document?

MR. TURK: Yes, Your Honor.

JUDGE FARRAR: Why don't we be -- given its legal status, why don't we introduce it rather than have us take judicial notice.

MR. TURK: That's fine. I'll have to make copies. I'll do that over the lunch break, Your Honor.

JUDGE FARRAR: On that basis, will there be any objection to its admission?

MS. NAKAHARA: No objection.

MR. GAUKLER: No objection.

JUDGE FARRAR: Thank you, Mr. Turk. Now it's the State's turn.

MS. CHANCELLOR: Your Honor, MS. Nakahara will be doing the bulk of the cross. At the end of her examination, I have a couple of questions, if that's acceptable to split it up?

JUDGE FARRAR: We generally discourage, to use a sports analogy, tag teams, but as long as it's kept within reasonable bounds, that will be fine.

MS. CHANCELLOR: It's just that the testimony crosses so many different areas.

JUDGE FARRAR: Right. And this is a difficult and complex case, and so we will allow more leeway than usual in that regard. Go ahead, Ms. Nakahara.

MS. NAKAHARA: Thank you, Your Honor.

CROSS EXAMINATION

BY MS. NAKAHARA:

Q. Good morning, Dr. Youngs and Dr. Tseng. For the record, I'm Connie Nakahara. I represent the State of Utah. I'll be asking you questions,

and I will either direct a question to both of you, and I'd like an answer from both of you or the appropriate person, or I will direct a question specifically to one of you. And I would just ask that you not confer before your initial answer.

This is for both of you. Do you both agree that PFS is proposing to store spent nuclear fuel in HI-STORM 100 dry storage casks? It's for both of you.

DR. YOUNGS: Yes.

DR. TSENG: Yes.

Q. Do you agree that under PFS's proposal, the casks will be freestanding or an anchor?

DR. YOUNGS: To my knowledge, yes.

DR. TSENG: Yes, I'm aware of that.

Q. Do you both agree that under PFS's proposal, the freestanding casks will be allowed to slide, rotate and uplift during an earthquake?

MR. GAUKLER: Objection, Your Honor. I think it's going beyond the scope of the direct, to get into the details of the cask. It did not get into the details of the cask, et cetera.

JUDGE FARRAR: This is preliminary and I'm not going to be in the business of sorting out which witness said which. If they can answer, they

can answer. If they can't -- the objection is overruled. You may answer.

DR. YOUNGS: To my knowledge, they are allowed to slide and tip.

DR. TSENG: Yes, my understanding is since it's an anchor, so it can be allowed to slide, possibly uplifted it, or tilt, yeah.

JUDGE FARRAR: Ms. Nakahara, let me respond further to Mr. Gaukler's objection. In the ordinary case, we do limit cross to the direct, but as I read the direct, all these different panels have worked together on different phases, and I think we lose more time trying to sort out exactly which one is the featured expert on each subject. If it gets beyond something that is preliminary and is not within their basic knowledge base, then that kind of objection might be well taken, but on these preliminary questions, I would think all -- there's a certain commonality of information that each of the panels knows about.

But again, for the benefit of all the witnesses, there's nothing wrong with an answer that says, I don't know. If your answer is I don't know, say I don't know, and that doesn't prove anything about your lack of expertise.

MR. GAUKLER: I point out to the record, we will be having the designers of the cask system testify, Dr. Singh and Dr. Soler.

MS. NAKAHARA: But I'd also like to point out that both Dr. Youngs and Dr. Tseng voice opinions on issues that rely upon the design concept of PFS.

JUDGE FARRAR: Right.

MS. NAKAHARA: As well as the --

JUDGE FARRAR: And that was the basis of our ruling. Go ahead.

MS. NAKAHARA: Thank you.

Q. (By Ms. Nakahara) Do both of you agree that these motions that allow sliding, rotating and uplifting will occur without any physical constraint?

DR. YOUNGS: The motions will -- I don't quite understand the question.

Q. Strike that. Let me ask it again.

Do both of you agree that PFS's proposal that allows freestanding casks to move will occur without any type of physical constraint during an earthquake on the casks?

DR. YOUNGS: It's my understanding that there is no -- the casks are not restrained.

DR. TSENG: It is my understanding that the cask is allowed to -- free to slide, no constraint, no physical constraints.

Q. And do both of you agree that under PFS's current design proposal, there is no redundancy to prevent cask tip over?

MR. GAUKLER: Objection, lack of -- ambiguous question. It's also outside the scope of the direct.

MS. NAKAHARA: It goes to the design and the presumptions on the foundation of their opinion.

MR. GAUKLER: It's going beyond the scope of the direct and it's getting into areas of design.

(Judges conferred off the record.)

JUDGE FARRAR: The objection is overruled. Let me explain how we're going to do this. I ask everybody to pay attention. There are four panels of witnesses. They deal with interrelated matters. Each one of them, as I remember -- I may be wrong. As I read their testimony, one fed information to another panel and they did something else. In other words, I understand that each panel dealt with a specific

aspect of the subject matter and they had their teams working on specific aspects, but they were interchanging information. One panel would do something based on what another said. In line with our golf analogy, we can't have an objection to every question, or we're going to be here forever. And these are basic questions I think these witnesses can answer. If it gets beyond your expertise, gentlemen, and anyone else, you say sorry, I didn't work on that, and we'd be happy to have the hint about who did work on it, and when those witnesses get on the stand, we'll ask about them.

Mr. Gaukler, if you think that these witnesses answer questions beyond their expertise, you're welcome when you put on the next set of witnesses, to say, these guys weren't really the experts, we are the experts and here's what we think. But we've got to move forward. These are basic questions. These people are -- as I read their testimony, hold themselves out as state-of-the-art experts on this general subject matter, and I think these questions are fair. So let's move on. Vicki, would you repeat the question, please.

(Question Read.)

JUDGE FARRAR: And before you answer that, if you don't understand -- this is what I'd like all counsel to do. If you don't understand the question, say so, because you're entitled to know. If the witnesses don't understand the question, say so. But this is a term that has been used in this industry and this regulatory process for decades, and so my assumption is that most people have an idea what this means. So go ahead and answer, unless you don't know what it means.

DR. YOUNGS: I do not know the details of the design, so I don't know whether there is a redundancy.

Q. (By Ms. Nakahara) Dr. Tseng?

DR. TSENG: Again, I'm not involved in the detail of the cask design, but as far as the movement per se, since it's not restrained, then certainly when the movement is watched, there's a potential for tip over. But it just like any design, if you have a large margin, then you won't tip over.

Q. Thank you. Do you both agree PFS's design proposal is to use cement treated soil under the pads?

DR. YOUNGS: To my knowledge, yes.

DR. TSENG: I didn't quite get your question. Could you repeat that again.

Q. That PFS's design proposal is to use cement treated soil under the pads?

DR. TSENG: Yes, I'm aware of that.

Q. Do you also both agree that PFS plans to use cement, soil cement around the pads?

DR. YOUNGS: To my knowledge, yes.

DR. TSENG: Yes, I'm aware of that.

Q. Do you both agree that the cement treated soil will be used as a structural element in the storage pads to transfer earthquakes to the foundation soil design?

MR. TURK: Objection, I'm not sure which soil cement or material you're talking about.

MS. NAKAHARA: Excuse me, I said soil cement.

MR. TURK: So you're talking about the material to the sides of the pad?

MS. NAKAHARA: Yes.

MR. TURK: Thank you.

MS. NAKAHARA: Could you read the question back.

(Question Read.)

MR. TURK: Your Honor, I have to object. The answer to my question was the opposite of what the question asked. And I have to point out also one request. It occurred in discovery, there was a blurring of the distinction between the CTB, the cask transfer building and the pads as well as the material under the foundations versus to the side of the foundations. So I would request if the question could be very specific as to which structure and which materials you're talking about, that would help us to have a clear record.

JUDGE FARRAR: And just so everyone's clear. Would it be simple just to refer to the pad in the one instance and the building in the other and we'll all know what's being talked about. And the different types of treatment, there are different mixtures that you refer to differently, and why don't we make sure we understand those differences. Are these the people who -- who can in the next 10 seconds provide those -- the soil cement, the cement treatment soil?

MR. GAUKLER: Your Honor, I don't believe so. I haven't discussed them. They're not all soil cement experts and I don't think they can.

JUDGE FARRAR: Then Ms. Nakahara, will

you be careful that we use the right term. Just so the record is clear, at this point, who wants to state which mixture is used under the pad and which is used to the side?

MS. NAKAHARA: Your Honor, it's my understanding, and counsel can disagree, but that cement treated soil is underneath the pad and soil cement is around, abuts the pad.

MR. TRAVIESO-DIAZ: The soil cement is also used around the building.

MS. NAKAHARA: So in this particular case, referring to one structure or another is not going to aid. I'll try to be --

JUDGE FARRAR: I'll ask counsel to do this: Just so we're sure there's no confusion, when you ask a question like that, refer to the mixture and the location you're talking about, just so we're sure that what you're asking and what the witnesses are answering is the same thing. It's kind of like a date, if you say, April -- it's Monday, April 29th and then there's no confusion. If you just say the date, somebody may misread it. So if you'll say what mixture you're talking about and where, to the extent that you can, as you introduce a line of inquiry, we'll save this kind

of confusion. Thanks.

MS. NAKAHARA: Thank you.

Q. (By Ms. Nakahara) I'll reask the question. Do you agree that the cement treated soil will be used as a structural element in the storage pads to transfer earthquake loads to the foundation soil?

DR. TSENG: Yes, I'm aware of that.

Q. Dr. Youngs?

DR. YOUNGS: I'm not familiar with the details of the design and what is considered to be transferring loads.

Q. Thank you. Do you both agree PFS's design also proposes to use soil cement around the canister transfer building to provide additional resistance to sliding?

MR. GAUKLER: Your Honor, neither of these witnesses have provided any testimony with respect to the canister transfer building. They only address points with respect to the D-1, which concerns the storage pad. D-2 concerns the canister transfer building.

MS. NAKAHARA: I'll withdraw my question.

Q. (By Ms. Nakahara) Do you agree that for

a 2000 year return period, earthquake at the PFS site, peak ground accelerations are 0.71g in the horizontal direction and 0.695 in the vertical direction?

DR. YOUNGS: I do.

DR. TSENG: Yes, I'm aware of that.

Q. Are either of you aware of any facility in the United States that has a similar design to PFS's design where spent nuclear fuel will be stored in freestanding casks or the pads are supported by cement treated soil and buttressed by soil cement?

DR. YOUNGS: I'm not familiar with the design of spent fuel, other spent fuel facilities.

Q. Dr. Tseng?

DR. TSENG: My own knowledge of what has been designed, I'm not aware of other facilities higher than this being designed as a freestanding. On the other hand, I think there are other facilities that have been entered that have been under design. So at the present time, maybe there's none, but I'm not sure that the final design will or will not.

Q. Dr. Tseng, just to clarify, when you say under, you mean there could be facilities that are

designed at ground motions that are less than PFS's 2000 year?

DR. TSENG: No, that's not what I mean.

Q. I'm sorry, could you explain.

DR. TSENG: There may be facilities under design that would have freestanding casks that have ground motion equal or maybe higher than the PFS site.

Q. To your knowledge, can you identify such a site?

DR. TSENG: I'm not involved in all the others, but from my own knowledge, that Diablo Canyon Power Plant is designing their storage facilities right now.

Q. Isn't it true that Pacific Gas & Electric proposes to anchor the storage casks at Diablo Canyon?

DR. TSENG: I personally am not aware of whether they want to be freestanding or anchored. In reading the documents and the testimony, I have come across that they possibly will propose for anchorage, but may not be the final design.

Q. Okay, thank you. Are both of you familiar with the term seismic category one?

DR. TSENG: Yes, I am familiar.

DR. YOUNGS: In what context?

Q. With respect to structures.

DR. YOUNGS: What types of structures?

Q. Nuclear power plant structure.

DR. YOUNGS: Yes.

Q. Are you aware of any structure at a nuclear power plant where seismic category one structures are not anchored and are allowed to freely slide, uplift and rotate when subject to strong ground motion?

DR. YOUNGS: I am not aware of the design of category one structures in detail. I'm not -- that's not my area of expertise.

DR. TSENG: Freestanding for category one structures, containment structure support only rock slide. It's bass mat is supported directly on rock. It's a freestanding structure. And containing structure is a category one structure.

Q. And at what facility are you referring to?

DR. TSENG: For all the nuclear plant I have deal with, all of them will be in a very competent site. The competence there will be near rock. So they would not need any pile or foundation element to anchor into rock. Most of

these plants will stand only rock or constructed directly on rock with thick bass mat with structure on top of it. And that is similar to like the freestanding structure, in a sense of no positive anchorage into the ground.

Q. But are you -- not but, strike that.

Are you aware of any seismic category one structure at a nuclear power plant that is not on -- that is allowed to -- strike that. Bad question.

Are you aware of any structure at a nuclear power plant where seismic category -- where a seismic category one structure is freestanding and is located not on bedrock?

DR. TSENG: For all the nuclear category one containment structures, certainly there will be on very competent formations, whether it's classified as rock or firm soil or soft rock, it will be a competent site, yes.

Q. Isn't it true that there is no rock or firm soil at foundation elevations at the PFS site?

DR. TSENG: The supporting elevation is soil for PFS site, at least for the pad itself, themself. But the soil has been cement treated underneath the pad. So it's -- it's stronger or

stiffer than the cement soil.

Q. Isn't it true that the cement treated soil is about one foot thick beneath the storage pad, cement treated soil?

DR. TSENG: Based on my understanding of the current design, yes, it's maybe one to two feet below the pads.

Q. And are you familiar with the type of soil or material that underlays the cement treated soil beneath the storage pad?

DR. TSENG: I'm familiar with the soil dynamics of properties that relate to seismic design for the pad. As far as the detail material per se, I'm not the expert in that.

Q. Thank you.

For both of you, isn't it true that storage pads at PFS are on a shallow foundation that is three feet deep?

DR. YOUNGS: It is my understanding that the pad design -- the pads will be three feet thick, yes.

Q. Dr. Tseng?

DR. TSENG: Yes.

Q. Are you aware of any structure at a nuclear power plant facility on soil sites with a

shallow embedded foundation of three feet or less with design motions with similar intensity as the PFS 2000 year design basis earthquake?

DR. YOUNGS: I'm not familiar with -- as I said, early design, detailed designs of facilities.

Q. Dr. Tseng?

DR. TSENG: My experience on other nuclear structures, nuclear power plant structures, certainly they are not in the same type of structure as we are talking about. The storage pad we are talking about is just simply a three feet thick, reinforced concrete slab. For a slab like that, it may happen in all other nuclear plant but not a structure per se. Structure, I mean building structures.

Q. Dr. Tseng, are you familiar with the settlement estimations by Stone & Webster over the design -- strike that.

Dr. Tseng, are you familiar with the PFS settlement estimations for the storage pad over the design life of the facility?

MR. GAUKLER: Objection, that's again beyond the scope of the testimony.

MS. NAKAHARA: This goes to his

estimations on the --

JUDGE FARRAR: The question was, are you familiar? The answer is yes or no.

DR. TSENG: I know Stone Webster have made calculation on estimate of settlements.

Q. (By Ms. Nakahara) Do you recall what the number was?

DR. TSENG: I have not reviewed in detail their calculation to know -- to remember the number that they have.

JUDGE FARRAR: Ms. Nakahara, give us a minute here.

MS. NAKAHARA: Okay.

(Judges conferred off the record.)

JUDGE FARRAR: Maybe counsel can help us with a situation that we think will be recurring here. A party may present testimony for a specific purpose, but cross-examination, we think is allowed on anything in that testimony whether or not it relates to the purpose that the party thought they put it forward for. In other words, the Applicant says this panel -- if your strategy was to present this panel to cover a certain subject, but in the course of their testimony they say a lot of things, for want of a better word, we think another party

can cross-examine them on those things, whether or not that relates to your strategy in putting it forward.

Mr. Gaukler, what do you think of what I just said? And remember, the fact that we say something doesn't mean we're committed to it. We're trying to run this in the best way we can, and so --

MR. GAUKLER: I guess I don't see how a lot of her questions go to the subject matter of their testimony. For example, there's nothing in their testimony on settlement. They're talking about specific issues that were raised by the State in the contention and they're identified in the beginning of their testimony.

JUDGE FARRAR: But they talk a lot about soil conditions and soil properties, which is my point. Regardless of why you put it forward, if they talk about it, why can't she ask them about it?

MR. GAUKLER: When they talk about condition soil, soil properties in the context of the claim raised by the State on damping, and underestimation of damping because the pad is rigid, those type of matters, they talk about them

in the context of the claims raised on -- I forget the exact situation, but they're talking about them in the context of the claims raised by the State. And like, for example, the settlement, there's nothing in there that relates to settlement in their testimony. And it's not even a seismic issue. They're really talking about seismic loadings, and in terms of loadings that were inputs that would then go into an analysis such as done by Holtec. And we are really getting far afield from what their testimony is about.

JUDGE FARRAR: Mr. Turk, does the Staff have any thoughts?

MR. TURK: Yes, Your Honor. I think in the simple case where there's one issue before the Board and each party brings a panel, then the panel should be able to cross-examine on everything in their testimony. Here, unfortunately, we're faced with multiple panels on a single issue or a single contention, and the Staff, for example, has cross-referenced in our testimony. There may be places where a witness on D says as stated in the testimony of our witness on E, here's the Staff's view. We do not mean by that to make our witness on D cross-examine I believe on what the other

witnesses on E are going to talk about. It's merely a reference.

And I think that's probably the same for the other parties' witnesses, as well. I think it would be helpful in cross-examination if the examiner refers to a specific question because it's hard to follow whether something is in the testimony or not, and then we can turn to the question and see whether it's merely a cross-reference or it's an affirmative statement by the witness. If it's an affirmative statement, then it should be cross-examinable, even if the purpose was not to make statement. But if the party put it in that testimony as an affirmative statement rather than simply to reference other peoples' testimony, then they've opened the door. But to do this, we have to see what's the question that the cross-examination is teeing off from, and I haven't heard that in the examination.

JUDGE FARRAR: Ms. Nakahara, anything to add before we lay down some ground rules.

MS. NAKAHARA: Yes, Your Honor. Both Dr. Youngs and Dr. Tseng proffer opinions on the magnitude of the effects of issues the State has raised. Their opinions on the magnitude depend in

this case -- in the State's -- the State poses that their opinions -- strike that. The State poses that the unique design, and both doctors' experience with this unique design and past precedent are relevant. With respect to pad settlement, it ties directly to the amount of flexibility in the storage pad that Dr. Tseng estimates later on in his testimony that I will address specifically. Right now, I'm just asking background questions on their familiarity with this unconventional design.

And one last point. Both Dr. Tseng and Dr. Youngs rely on other calculations and assumptions made by other experts, other experts rely on their analysis and it's all interrelated, and it's impossible to get to the merits without asking these questions.

MR. TRAVIESO-DIAZ: May I make a statement for clarification only?

JUDGE FARRAR: No.

(Judges conferred off the record.)

JUDGE FARRAR: Let's lay down some ground rules here in accordance with your suggestions and our thoughts. First, wherever possible, we want counsel to identify, as has been

done on previous issues in the case, identify the question and answer and the witness's testimony that you're focusing on, if indeed, you are focusing on one. If you're not focusing on it, you can't.

Second, I'd ask these witnesses and any witnesses, when a question comes up and there's an issue about whether it's within your competence or some other panel's, tell us. In other words, yes, I'm aware but that was done by somebody else and I can't speak to it. Then we know that this question will later be addressed to the other people. So rather than have an objection, an argument and us spend 10 minutes trying to decide whether this is within the witness's testimony, the witnesses will tell us if it's within their expertise. I think that way it's going to be fair and we're going to save not the 10 seconds, but we're going to save 10 minutes on every shot, going back to our golf analogy.

So I ask counsel now, if at some point, the witness gives an answer that some counsel is really distressed about, because it doesn't explain how your indication hangs together, fine, speak up. But I want this thing to get moving. These are

fair questions, they're background questions and these are expert -- these are world class experts, at least that's how each party bills their experts. They can answer these questions. There's not a jury, we are not going to get confused. Let's get the answer.

Go ahead, Ms. Nakahara. While we were conferring, somebody wanted to say something.

MR. TRAVIESO-DIAZ: Yes, I did, and I think it's an important thing. I think what Ms. Nakahara is asking about is the long-term settlement of pads over periods of time. It's like a matter of time, 20 and 30. That is first of all, not a seismic issue whatsoever. It is the behavior of structures over time. So it's outside the scope of the direct. I'm certain that it's not in the testimony of any witness. There were long-term settlement of pads. So I think we are distressed by this line of questions.

JUDGE FARRAR: I'll repeat the point, the witness could have answered that far faster than you can. These are good witnesses, they know what they're talking about and the fact that they answer a question that you think is not part of the contention, you can then at some point -- maybe it

has to be now, maybe it's in your proposed findings that that's not an issue in the case. But these are background information. The State would like the hearings to be here. If your Applicant is like most applicants over the history of regulation in this industry, they want a decision fast. If we keep getting these interruptions, that decision is going to go longer and longer and longer into the distance, not because of our fault or not because we have any dislike for your client, but because we're never going to finish this hearing. It's faster to ask the questions, get the answer and move on. We've hardly begun. We're only in the very background stages and we can't get moving. Now, make objections when they're really serious. If we're talking about background, let the witnesses answer and maybe we'll argue about it later. Ask a question.

MS. NAKAHARA: I'd like to have marked as States Exhibit 168, which is Pages 2.6-50 and 2.6-51 out of the Safety Analysis Report for PFS Revision 22.

(EXHIBIT-168 MARKED.)

Q. (By Ms. Nakahara) Dr. Tseng --

JUDGE FARRAR: Ms. Nakahara, let me

modify a previous remark. When I said the Applicant like decisions in a hurry, that's their general approach. That does not, of course, in any way indicate that we have any idea at this point which way that decision will go up. They just generally like decisions sooner rather than later. There's no -- that was not meant to suggest in any way, as all the parties know, that any decision we issue would be favorable or unfavorable, but they do like them in a hurry. Go ahead.

Q. (By Ms. Nakahara) Dr. Tseng, have you had an opportunity to briefly review this document?

DR. TSENG: I have not reviewed this before, but I'm looking at it now.

Q. I only have one question for you, so is it okay if I pose my question while you review the document? Isn't it true this document estimates maximum total settlement for the storage pads to be approximately 1.7 inches?

DR. TSENG: The answer to your question is yes.

Q. Dr. Tseng, are you aware of any nuclear structures where settlement of 1.7 inches or more were anticipated during the design life of the facility?

DR. TSENG: My experience generally involves seismic, and long-term settlement estimate is not my expertise, so I'm not aware of that.

Q. Okay, thank you.

Dr. Tseng, are you aware of any nuclear structure where soil cement has been used to resist seismic loading of that structure?

MR. TURK: Soil cement as opposed to cement treated soil under a foundation?

MS. NAKAHARA: Yes, soil cement in abutment to the foundation.

DR. TSENG: Again, this relate to a lot of foundation design which are technical issues. I'm not the best person to answer these questions.

Q. (By Ms. Nakahara) And then for both of you, isn't it true you have not worked on a project other than at the PFS site, where spent nuclear fuel will be stored in unanchored casks where a structure uses cement treated soil under the pad to resist sliding and where ground motions exceed or equal those at the PFS site for the 2000 year design basis earthquake? I'm sorry for the length of that. Would you like it reread.

DR. YOUNGS: Yes, please.

(Question Read.)

DR. YOUNGS: I am currently involved in work on the Diablo Canyon Power Plant, and I do not know any details of what designs they may or may not be considering for -- as a part of their placement process. And those -- this site and that site are the sites where I've worked on spent nuclear fuel.

Q. And Dr. Youngs, what is the peak ground acceleration at Diablo Canyon?

DR. YOUNGS: You mean at Yucca Mountain?

Q. Yes. Did I said Diablo?

DR. YOUNGS: Yes.

Q. I'm sorry.

DR. YOUNGS: I have not worked at Diablo Canyon.

Q. And what are the peak ground accelerations at Yucca Mountain?

DR. YOUNGS: I don't remember all the -- I know there are numbers that range from half a g to over a g in various locations.

Q. And --

DR. TSENG: For me, the answer to your question is yes, this is the first project that I worked on.

Q. Thank you. Dr. Youngs, in Answer 16 of

your testimony, isn't it true that the reference probability used for establishing the design ground motions for the PFS site are not equivalent to those required for nuclear power plants?

DR. YOUNGS: Yes, it is true.

Q. Are you familiar with NUREG 1.165?

DR. YOUNGS: Yes.

Q. Isn't it true that NUREG 1.165 states the reference probability for nuclear power plants as a hundred thousand year earthquake?

MR. GAUKLER: Just for clarification, I think counsel meant to say Reg Guide 1.165.

MS. NAKAHARA: Oh, I did, thank you.

MR. TURK: And I would object, the question is very imprecise. I think if counsel would read from the document, we would be better off, the record would be much better. It's not a correct quotation.

MS. NAKAHARA: I wasn't quoting.

JUDGE FARRAR: If you can, that would be a better -- you don't have to do it, but it would be a better practice ordinarily to do that.

Q. (By Ms. Nakahara) I'll withdraw the question.

Dr. Youngs, will you explain what the

reference probability for a nuclear power plant is?

DR. YOUNGS: The reg -- the reg guide 1.165 indicates a reference probability for a problematic seismic hazard result for the selected design level for a nuclear -- commercial nuclear power plant.

Q. And what is that standard?

DR. YOUNGS: The recommended value in that reg guide is the median ten to the minus five annual probability level.

Q. Thank you. Dr. Youngs --

JUDGE FARRAR: And so the record is clear, that's 10,000 years?

DR. YOUNGS: A hundred thousand years. Ten to the minus five.

JUDGE FARRAR: Right.

MR. TURK: But the distinction -- Sherwin Turk. The answer made clear whether it was a mean or median value, which will be an issue you look at later under Part D. The question didn't have that component in it.

Q. (By Ms. Nakahara) Dr. Youngs, isn't is true that the PFS facility is the only nuclear facility where you have generated time histories with the peak ground acceleration greater than 0.4

Gs?

DR. YOUNGS: That is correct.

Q. In your answer to Question 13, you discuss Geomatrix developed soil properties to be used in the dynamic analysis. In addition, you discuss Geomatrix developed mass, soil spring and soil damping values to be used for dynamic analyses of storage pads. Did you provide these analyses to Holtec to use in the casks response analysis?

DR. YOUNGS: We provided the annual -- the results of the analysis to Stone & Webster to distribute to the appropriate people using them.

Q. To your knowledge, do you know whether Holtec used your calculations directly or whether they performed additional calculations or modifications to your analysis?

DR. YOUNGS: I have not reviewed their calculation.

Q. Dr. Youngs, isn't it true that you provided a single set of free field time histories for a 2000 year return period at the PFS site?

DR. YOUNGS: That is correct.

Q. Are you aware whether Holtec used -- whether Holtec used a single set of time histories that you developed as input into its casks ability

analysis?

DR. YOUNGS: I have not reviewed their calculations in detail.

Q. Isn't it also true that PFS directed you to generate a single set of time histories for the PFS site?

DR. YOUNGS: Yes, we were asked to generate one set following the standard requirements.

Q. Dr. Youngs, are you aware that Holtec's cask ability analysis is a non linear analysis?

DR. YOUNGS: Yes, I'm aware of that.

MS. NAKAHARA: Your Honor, I apologize, I'm losing my 10 seconds plus.

I'd like to have marked as State's Exhibit 169 -- I apologize for this copy, it was taken from a deposition exhibit. So it already has an exhibit number on it, an incorrect exhibit number on it.

(EXHIBIT-169 MARKED.)

JUDGE FARRAR: All right, the reporter has marked the exhibit for identification. Go ahead.

Q. (By Ms. Nakahara) State's Exhibit 169 is the cover page of the American Society of Civil

Engineers, Seismic Analysis of Safety Related Nuclear Structures and Commentary, ASCE 4-98 and pages 19 and 20.

Dr. Youngs, are you familiar with this document, or these pages?

DR. YOUNGS: Yes, I have seen them before.

Q. Are you familiar with ASCE 4-98, Section 3.2.2.3 non linear methods?

DR. YOUNGS: Not in detail, no. I've read it before.

Q. Will you read Subparagraph A, the first sentence.

DR. YOUNGS: "When performing a nonlinear analysis, the following shall be considered:"

Q. I guess it doesn't mean anything without the rest of it, sorry.

DR. YOUNGS: "One, geometric nonlinearity that significantly alter the effective system for geometry such as large displacements or significant gaps. Two, material nonlinearity such as plasticity or friction in the range of response under consideration."

Q. And Dr. Youngs, will you also read

Subparagraph D.

DR. YOUNGS: "In general, more than one set of acceleration history meeting the requirements of Section 2.3 should be used and the results of the analysis shall be averaged."

Q. Isn't it correct that ASCE 4-98, Section 3.2.2.3 requires more than one set of time histories to be used for a nonlinear analysis?

DR. YOUNGS: The statement as I read it says in general, they should be used. It doesn't seem to be a requirement.

Q. The next questions relate to PFS Exhibit LL. Dr. Youngs, isn't it true that you are the originator of PFS Exhibit LL entitled Geomatrix Evaluation, a Spatial and Temporal Variation Motion for the Private Fuel Storage facility, Skull Valley, Utah?

DR. YOUNGS: I am the primary author, yes.

Q. And isn't it true in this exhibit, you estimated the angle of incidence at which seismic waves would strike the PFS facility?

DR. YOUNGS: That is true.

Q. Is it correct that to estimate the angle of incidents, you used a ray tracing method?

DR. YOUNGS: Correct.

Q. In your answer to Question 42, isn't it correct that you state, "as a further check, I asked Dr. Walter Silva to perform several test calculations using his ray tracing computer program"?

DR. YOUNGS: That is correct.

Q. Have you reproduced Dr. Silva's calculations anywhere in your testimony?

DR. YOUNGS: No.

Q. Isn't it true that no other PFS witness will be testifying about ray tracing methodology in this hearing?

DR. YOUNGS: I don't know all the witnesses that will be testifying.

Q. To your knowledge --

DR. YOUNGS: To my knowledge, it's true.

Q. Can you describe -- will you describe what calculations you asked Dr. Silva to perform?

DR. YOUNGS: I asked Dr. Silva to calculate angles of incidence for an initial velocity -- set of velocity profiles and locations to verify that my calculations were correct.

Q. And do you have any written documentation of Dr. Silva's calculations?

DR. YOUNGS: I have an E-mail he sent me with his results that he calculated for a particular set of profiles.

MS. NAKAHARA: Barring examination of the E-mail, we'd move to strike this sentence referring to Dr. Silva's confirmation. And I'd suggest that the E-mail would be the best evidence. Dr. Youngs can provide us some more detail.

MR. GAUKLER: Your Honor, we have no problem finding the E-mail if the State wants it. But, you know, more in the sense of validation of his computer program that he was using, so we didn't see the need to get into all that detail.

JUDGE FARRAR: Does the Staff have anything?

MR. TURK: Nothing significant, Your Honor. I should tell you, I always have an opinion. I've learned sometimes it's wiser not always to express it.

(Judges conferred off the record.)

JUDGE FARRAR: There is some range for experts to rely on the opinions of other experts with whom they talk and so forth, but in this case, if we can get the E-mail, that would --

MR. GAUKLER: We can provide it to the

State and they can do what they want to do with it.

JUDGE FARRAR: That would add. But you're always looking for the best you can get and if the E-mail adds something, let's get it in there. So we will deny the motion to strike at this point.

MS. NAKAHARA: Thank you, Your Honor.

Q. (By Ms. Nakahara) Dr. Youngs, isn't it correct that your calculation of the ray path accounts only for shear SH-waves?

DR. YOUNGS: I do not believe that's correct. It accounts for shear waves.

Q. So is it your opinion that it accounts for -- it also accounts for SV-waves.

DR. YOUNGS: That's my opinion, yes.

Q. And is it also your opinion that it accounts for P-waves?

DR. YOUNGS: P-waves would be moving in a different velocity, so it does not account for P-waves.

Q. Did you perform a ray path calculation to account for P-waves?

DR. YOUNGS: No.

Q. Is it your testimony that all waves striking the foundation facility are all

essentially vertically propagating waves?

DR. YOUNGS: It's my testimony that they are -- that they are nearly vertical, yes.

Q. And that there are no other forms and types of waves, other than those you've considered and other than the P-waves?

DR. YOUNGS: I do not believe I stated that in the --

Q. Do you believe there are other forms and types of waves other than shear waves and P-waves?

DR. YOUNGS: There are other forms of other waves that occur in earthquakes, yes.

Q. And what types of waves are those?

DR. YOUNGS: As one moves well away from -- well away from the source, you get the presence of surface waves.

Q. 7did you quantify the effect of the angle of incidence to the response of the casks on the pads?

DR. YOUNGS: Yes, we did that.

Q. In the casks ability analysis?

DR. YOUNGS: For -- quantified it in terms of -- in our -- in this -- in this exhibit, we quantified it in terms of a percent differences in motions.

Q. But you did not -- is it correct that you did not quantify the actual effect of non vertically propagating waves to the cask's response in the casks ability analysis?

DR. YOUNGS: That is correct.

Q. Isn't it correct that your evaluation in PFS Exhibit LL is based on the dominant frequencies of the cask's response determined from the dynamic response time histories provided to you by Holtec?

DR. YOUNGS: That is correct.

Q. And this is with respect to Answer 44.

And isn't it true that these dynamic response time histories were generated from the Holtec analysis described in the multi cask response for a 2000 year earthquake -- and I don't believe that's -- thank you. Strike that.

Isn't it true that these dynamic response time histories were generated from the Holtec analysis described in the document entitled Multi Cask Response at the PFS FEIS for the 2000 year seismic document, Document No. HI-23012640 revision two?

DR. YOUNGS: I will have to look exactly. I cannot verify from the documentation here exactly what document the time histories came

from.

Q. Okay, thank you.

Were these dynamic response time histories generated from the lower bound soil parameters?

DR. YOUNGS: Again, I cannot document or verify exactly which case these time histories were developed from.

Q. Have you evaluated whether the casks response in Holtec's nonlinear analysis is sensitive to small changes in input data?

DR. YOUNGS: Can you please repeat the question.

Q. Have you evaluated whether the casks response in Holtec's nonlinear analysis is sensitive to small changes in input data?

DR. YOUNGS: In detail, no.

Q. Would your analysis change if the cask's response would substantially change based on small changes in input data?

DR. YOUNGS: It would depend upon what types of changes and what types of data.

Q. If the cask's response frequency was, in fact, different than what was provided to you by Holtec, would your conclusion concerning the angle

of incidence change?

DR. YOUNGS: If the -- can you please --

Q. If the cask's response frequency was, in fact, different than what was provided to you by Holtec, would your conclusion concerning the angle of -- the importance of the angle of incidence change?

DR. YOUNGS: It would depend upon what the frequency was.

Q. If the frequency increased beyond five hertz -- the frequency of interest increased beyond five hertz, would that change your opinion?

DR. YOUNGS: No, because that would imply the angles would get much smaller.

Q. If the frequency of interest went below one hertz, would that change your opinion?

DR. YOUNGS: It would depend on if it went -- how far it went.

Q. In Answer 54, you refer to an article by Wong and Luco for inclined SV and P-wave effects; is that correct?

DR. YOUNGS: Which again, excuse me?

Q. Answer 54.

DR. YOUNGS: Yes.

Q. Do you agree that the Wong and Luco

solution is for a rigid mat and uniform elastic half space? If you like, I have a copy of the --

DR. YOUNGS: I have a copy here. I'm not familiar with the details of this portion of the assessment because it was done by others in our core. But it's my understanding that it's a half space solution for a rigid mat.

Q. Thank you.

Is the PFS site a uniform elastic half space? Does it meet the definition of a uniform elastic half space?

DR. YOUNGS: It would depend on the context of the evaluation.

Q. Isn't it true that the PFS site has variability in soil, in its soil layers?

DR. YOUNGS: In the layer in which variability -- yes, there is variability. Primarily, there's an increase in velocity with depth.

Q. Is there a uniform increase in velocity with depth or a nonuniform increase?

DR. YOUNGS: The increase is not constant with it. It varies.

Q. Have you prepared any calculations for the actual site conditions at the PFS site where

the soil strata is not homogeneous to show that -- to show the effects of inclining waves?

DR. YOUNGS: No.

Q. Have you quantified the effects of incline waves on a cask or pad that is already sliding under seismic ground motions at the PFS site?

DR. YOUNGS: No.

Q. Have you quantified the effects of incline waves on a cask that is already uplifting under seismic ground motions at the PFS site?

DR. YOUNGS: No.

Q. Have you quantified the effects of incline waves on a cask or pad that is already rotating under seismic ground motions at the PFS site?

DR. YOUNGS: What we have quantified here are the effects of changes in motion due to incline waves over vertical waves. I do not know the details of the Wong and Luco formulation, whether or not motions are already occurring. Presumably they're already occurring in the process. So whether they are already rotating or not, it's not quite clear to me.

DR. TSENG: I might add to this

clarification. Luco and Wong's paper indeed is for a uniform half space solution. The solution itself doesn't necessarily fit exactly the site condition, but on the other hand, you can use the equivalent uniform shear wave velocity, if you will, to evaluate the effect of this only pad that what the incline wave length effect on the pad. Now, the quantification here is referring to the degree of change in the motion with these -- at some more a small incline wave versus a strongly vertical propagating wave. And the quantification is in terms of percentage change. If you use the incline wave, how much percent you would obtain, say, additional like a torsion motion or a rocking motion. And that quantification turned out to be in the order of, oh, less than five percent.

And that's the message or at least the conclusion one could draw, that even though there is no direct analysis of the site, based on the Luco and Wong's published result, we can draw some judgment as to how this small variation of vertical degree that was up to 10 degree angle would have on the motion of the pad. And that inference certainly would then affect, although we did not look into what kind of effect on the cask's

response, but with a small change in motion, we make a judgment effect that the cask's response would also be small.

Q. Thank you.

Earlier, Mr. Turk asked you your familiarity with the computer code SASSI. Do you agree that SASSI is capable of evaluating the effects of incline waves? For either of you.

DR. TSENG: I, myself, is familiar with SASSI computer program, and it could evaluate incline wave in a very pure wave form. Not a combination of different waves, if it to evaluate analysis in order to do combination of different type of waves.

Q. Dr. Tseng, would you describe what you mean by pure wave form?

DR. TSENG: For example, if you assume the wave has come in at 10 degrees, it will have to be all in SV-wave or it will all be in SH-wave, and if you have to combine those in a more realistic form, then you have to perform a lot more analysis and combination. It's not a straightforward for realistic case.

Q. And isn't it true that neither of you use SASSI to evaluate the effect of incline waves

on the pad motion for the site specific conditions at the PFS site?

DR. TSENG: For the PFS site, that's true, yes.

DR. YOUNGS: That's true.

Q. (By Ms. Nakahara) I don't expect you have the State's Exhibit available, do you, State's Exhibit 118?

MR. GAUKLER: I don't think they do.

Q. (By Ms. Nakahara) It's different pages to.

DR. YOUNGS: Oh, different pages?

Q. Yeah. This is State's -- pre-marked State's Exhibit 118, which is a cover page for the American Society of Civil Engineers, Seismic Analysis of Safety Related Nuclear Structures and Commentary ASCE 4-98 and pages 119, 20 and 25.

JUDGE FARRAR: And this is the same document or different excerpts from the same document you handed out before?

MS. NAKAHARA: Yes, it's different. I take that back, Your Honor. This is the same. If I could have one --

JUDGE FARRAR: The pages are different.

JUDGE LAM: It has one more page.

JUDGE FARRAR: State 169 for identification had pages 19 and 20. This has page 119, 20 and 25.

MS. NAKAHARA: I apologize.

JUDGE FARRAR: That's all right. There's a lot of documents in this case. That's all right. Just use State 118, that's fine. Let's straighten this out off the record.

(A discussion was held off the record.)

Q. (By Ms. Nakahara) I apologize. If you look on Page 25, are you familiar with Section 3.3.1.2, spatial variations of free field motion? Dr. Tseng or Dr. Youngs, either of you?

DR. TSENG: Yes, I'm familiar.

Q. Would you read subparagraph A into the record, please.

DR. TSENG: A vertical propagating shear and compression waves may be assumed for an SSI analysis, provided that torsional effect due to non vertical propagating wave are conceded. The consideration of an accidental history of five percent of the structures planned dimension as discussed in Section 3.1.1 are fully torsional effects.

Q. And to your knowledge, was the accident,

the accidental history of five percent accounted for in the design of the pad and in the cask response calculation?

DR. TSENG: As far as my knowledge is concerned, for the pad design, the effect itself is, because the pad is rested already on the ground and resist by the ground, so the application of that five percent have no consequence on the design per se. As far as cask's response itself, I, myself, am not aware of whether they have or have not included that five percent.

Q. Thank you.

MS. NAKAHARA: And, Your Honor, I assume you'll stop me when I'm ready for a break? I'm just going to another section.

JUDGE FARRAR: All right. Let me ask off the record a question about this exhibit.

(A discussion was held off the record.)

JUDGE FARRAR: Since we said we're going to go until five, does it make sense to take a lunch break now, or do you have just a short amount left that you could finish before lunch?

MS. NAKAHARA: Unfortunately not, but I do have two housekeeping items. I forgot to move the admission of the exhibits.

JUDGE FARRAR: Go ahead.

MS. NAKAHARA: I'd like to offer into the record or move into the record, State's Exhibit 168, which is Pages 2.6-50 and 51 of the Safety Analysis Report for PFS Revision 22.

MR. GAUKLER: We raise the objection, that it's beyond the scope of the contention.

MS. NAKAHARA: And I can withhold moving this exhibit until later, where I hope to show --

JUDGE FARRAR: Which one are you talking about now? 168 or 169?

MS. NAKAHARA: 168. If Your Honor would prefer, I can withhold it until later.

JUDGE FARRAR: You're going to tie this in later through some other witness?

MS. NAKAHARA: Yes.

JUDGE FARRAR: Okay, then I'll hold that motion. How about 169?

MS. NAKAHARA: I'd like to move admission of 169 into the record.

JUDGE FARRAR: Any objection?

MR. GAUKLER: No objection, Your Honor.

MR. TURK: None, Your Honor.

JUDGE FARRAR: Okay, that will be admitted.

(EXHIBIT-169 ADMITTED.)

JUDGE FARRAR: Ms. Nakahara, you have how much more left?

MS. NAKAHARA: I have at least a couple -- I'm probably worse than all counsel combined in underestimating how long it will take. I would say two to three hours.

JUDGE FARRAR: Okay. That being the case, you've been moving along reasonably well so far. Maybe you can do that in less time, maybe not, we'll see. Why don't we -- it's now 10 after 12. Let's come back at 10 after one.

(Noon Recess.)

JUDGE FARRAR: All right. We are back on the record. I see that everyone is here. Before the break, Ms. Nakahara, I think you told me you were near the very end of your cross-examination.

MS. NAKAHARA: Only if PFS withdraws.

CONTINUED EXAMINATION

BY MS. NAKAHARA:

Q. The next area I'd like to ask questions about is pad flexibility and deflection. Dr. Tseng, is it correct you reviewed the storage pad